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THIRD SERIES FOUNDED BY EDWARD JACKSON

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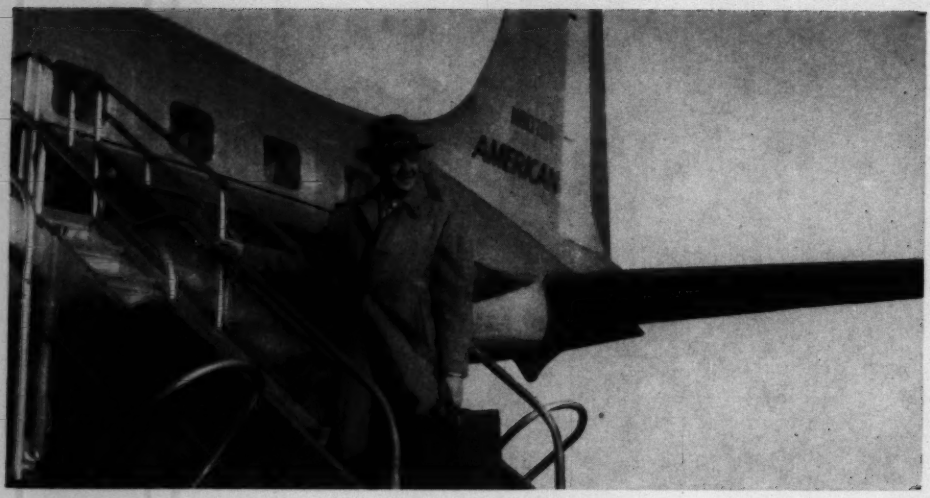

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REPORT ON TRIAMCINOLONE

J.A.M.A. 169:257 (January 17) 1959.

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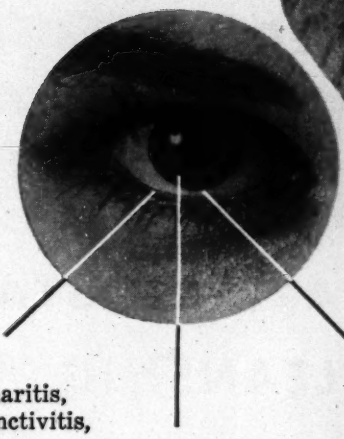

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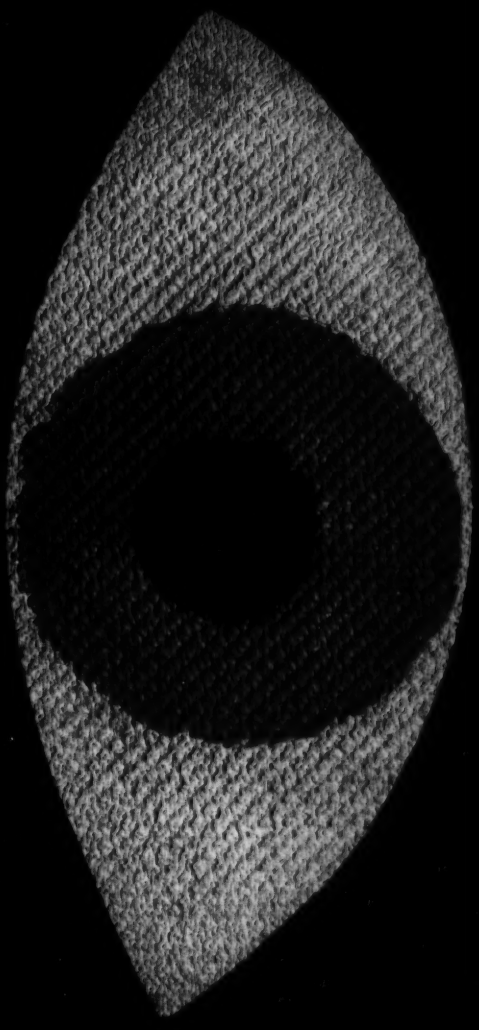

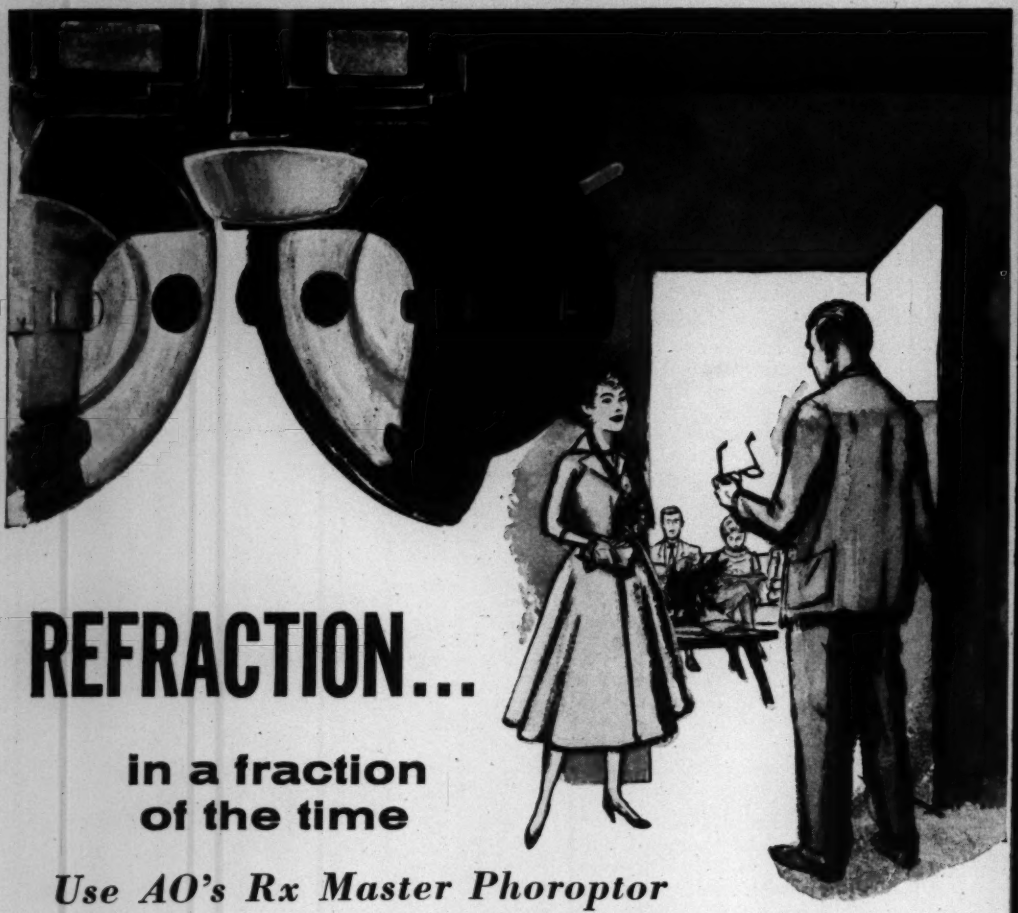

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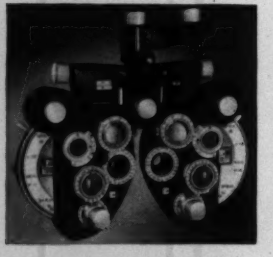

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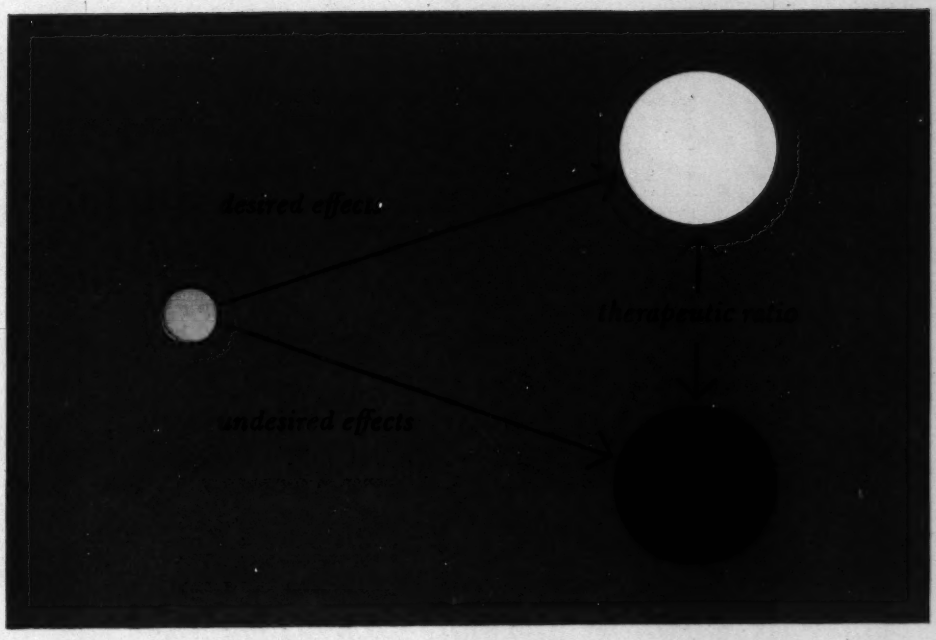

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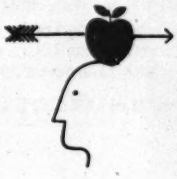

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1. Neustadt, D. H.: Corticosteroid Therapy in Rheumatoid Arthritis: Comparative Study of Effects of Prednisone and Prednisolone, Methylprednisolone, Triamcinolone and Dexamethasone, J.A.M.A., in press.

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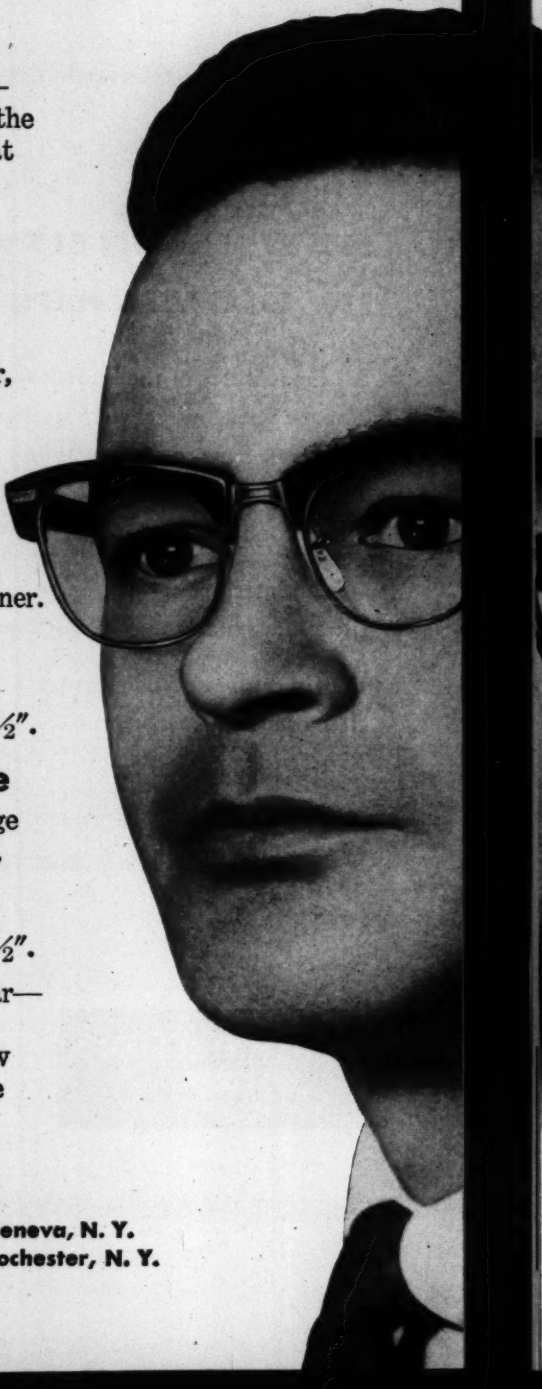

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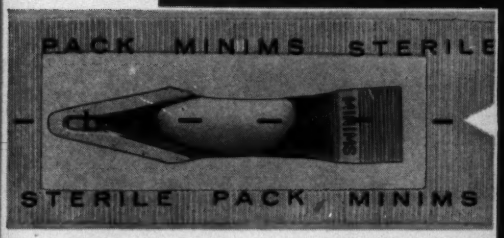

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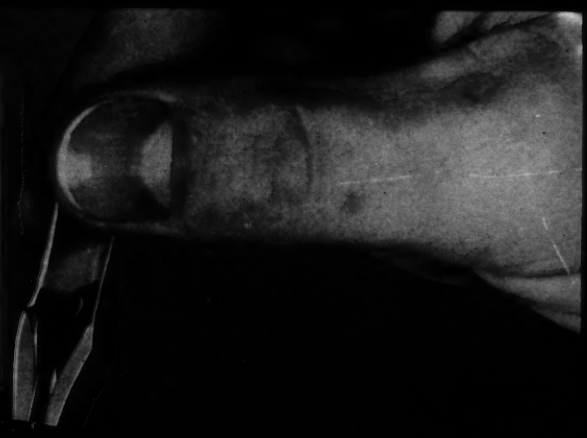

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AMERICAN JOURNAL OF OPHTHALMOLOGY

VOLUME 47 JUNE, 1959 NUMBER 6

OCULAR MANIFESTATIONS OF INSUFFICIENCY OR THROMBOSIS OF THE INTERNAL CAROTID ARTERY*

ROBERT W. HOLLENHORST, M.D.
Rochester, Minnesota

The syndromes of intermittent insufficiency and of thrombosis of the carotid arterial system are of great interest to ophthalmologists because of the frequent association of ocular involvement. This report concerns 124 patients, of whom 38 had thrombosis of one or both internal carotid arteries, 80 had symptoms or signs of intermittent insufficiency of one or both internal carotid arteries, and six had symptoms of amaurosis fugax only.

The important contributions of Millikan and Siekert[1] and of Millikan, Siekert, and Shick[2] emphasized the necessity of recognizing the earliest signs of impending thrombosis before actual infarction had taken place in the brain. They showed that transient episodes of neurologic deficit may occur suddenly and may remain for two to 15 minutes; the patient then slowly returns to normal without demonstrable physical signs of the episode. Such attacks are nearly always unilateral, and the pattern of the attack is usually similar during each repetition. Transient paresis of one arm or one leg, or oftener of both the arm and leg, may occur. Hemianesthesia occurs more commonly in the hand or forearm of the affected side if at all. Sometimes both hemiparesis and hemianesthesia develop, with paresis or numbness of one side of the face or of the lip on one side. If the lesion is in the left internal carotid artery, there may be transient attacks of aphasia too. The visual pathways are often affected, and there may be transient brief diminution or loss of vision (amaurosis fugax) in the eye on the side of the affected artery, or a transient homonymous hemianopsia to the opposite side. These episodes may recur as often as eight to 10 times daily, although an interval of a month or two months between attacks is not unusual. Such attacks may go on for weeks or years, but at some time most of them probably terminate in thrombosis of the carotid artery and infarction of the brain. Unfortunately, not all impending thromboses give advance warning, and a sudden onset of "stroke" may be the first indication that atherosclerotic or embolic changes have occurred.

I am indebted to my colleagues, Dr. C. W. Rucker and Dr. T. P. Kearns, who saw many of these patients with me and extended to me the benefit of their experience and advice, and who also examined the patients whom I did not see personally. I am indebted to Dr. C. H. Millikan, Dr. R. G. Siekert, and Dr. J. P. Whisnant of the Section of Neurology who called these problems to my attention, conducted the diagnostic examinations, and directed the therapy.

In the group of 124 cases, only one case of intermittent insufficiency and 13 cases of thrombosis of the carotid arteries were proved by angiography. However, the symptoms and clinical signs in most of the other cases were so characteristic that exposing the patients to the hazards of angiography

* From the Section of Ophthalmology, the Mayo Clinic and the Mayo Foundation. The Mayo Foundation, Rochester, Minnesota, is a part of the Graduate School of the University of Minnesota. This paper is an abridgement of the thesis submitted for membership in the American Ophthalmological Society and published in the *Transactions* of the American Ophthalmological Society, 1958.

TABLE 1

OCULAR ABNORMALITIES IN 124 CASES OF THROMBOSIS OR INSUFFICIENCY OF THE CAROTID ARTERIES

Ocular Abnormalities	Intermittent Insufficiency		Thrombosis	
	Number of Cases	Per Cent	Number of Cases	Per Cent
With ocular signs and symptoms	58	67	22	58
Without ocular signs and symptoms	28	33	16	42
TOTAL	86		38	

did not seem justified. The excellent therapeutic response obtained when anticoagulant therapy was given bore out the accuracy of the diagnosis. It was not possible, understandably, to be sure as to the exact extent and site of the occlusive process in the carotid vessels. Reasonable assurance that the diagnosis was correct was obtained by comparing signs and symptoms of these patients with those encountered among patients in whom insufficiency or thrombosis of the carotid artery had been verified by necropsy or angiography or both.

Table 1 shows that ocular signs and symptoms are seen more frequently in patients having intermittent insufficiencies of the carotid artery than in patients having thrombosis of the carotid artery. The criteria used for dividing the group were more or less arbitrary and so there may be some overlapping in so far as clinical data are concerned. The 86 patients who were classified as having intermittent insufficiency of the carotid artery were those who complained of transient episodes of visual loss, hemiparesis, hemianesthesia, or aphasia. The 38 patients classified as having thrombosis of the carotid artery were those who had experienced sudden onset of severe hemianesthesia, hemiplegia, homonymous hemianopsia, or aphasia from which they did not recover or else recovered slowly over a period of months.

The frequency with which left and right sides were affected was about equal as is seen in Table 2. In a small group of patients both sides were thought to be affected. The age distribution was essentially similar in the two groups. The ages ranged from 41 through 78 years, with the greatest incidence of insufficiencies occurring among patients 50 to 69 years of age. Thrombosis of the carotid artery seemed to occur with about equal frequency in each decade among patients 41 to 69 years of age. Approximately half of each of the two groups of patients had hypertensive cardiovascular disease, all of Keith-Wagener groups I and II, and none of the groups III or IV.

A summary of the incidence of the ocular signs and symptoms which appeared in these two groups is given in Table 3.

The pressures in the retinal arteries were measured with the ophthalmodynamometer

TABLE 2

LATERALITY OF THROMBOSIS OR INSUFFICIENCY OF THE CAROTID ARTERIES

Proof	Insufficiency			Thrombosis		
	Right	Left	Both	Right	Left	Both
	41	37	8	19	17	2
By angiography	0	1	0	7	5	1
By necropsy	0	0	0	1	3	0

TABLE 3

OCULAR SIGNS AND SYMPTOMS OF INSUFFICIENCY OR THROMBOSIS OF THE CAROTID ARTERY IN 124 CASES

Ocular Signs and Symptoms	Insufficiency (86 cases)	Thrombosis (38 cases)
Amaurosis fugax	48	2
Unilateral retinopathy	11	4
Unequal retinal hypertensive vascular changes in the two eyes	8	2
Homonymous hemianopsia		
Transient	2	1
Permanent	2	6
Homonymous hemianopic hallucinations	3	0
Occlusion of retinal artery	8	6
With contralateral homonymous hemianopsia	4	2
Pupil smaller on affected side	1	1

of Bailliart in all patients except some who had sustained occlusion of a branch artery. Pressures were not determined in these latter patients because of fear (perhaps unfounded) that the exertion of pressure on an eye which had already sustained partial occlusion might produce a greater loss of vision. The results of these measurements are given in Table 4.

AMAUROSIS FUGAX

The incidence of transient unilateral loss of vision was found to be much higher among patients having intermittent insufficiency than among those having thrombosis. The symptoms of six patients consisted solely of transient episodes of visual loss. All six had noted these attacks for several months; the frequency varied from 10 or 12 attacks daily in several patients to one or two attacks monthly in others. Five of the six were treated with anticoagulants (Dicumarol), and all five had immediate relief for the duration of treatment. Termination of treatment resulted in recurrence of symptoms in two patients, so treatment was resumed. Three had right-sided and three had left-sided involvement. Three patients had significantly lower pressure in the retinal artery on the affected side and the other three had equal pressures on the two sides. The case of one of the three patients having equal pressures on the two sides is interesting and is presented herewith:

CASE 1

In December, 1956, a 54-year-old man was seen who complained of attacks of transient visual loss in the left eye three to six times daily for the previous three weeks. Each attack consisted of sudden complete loss of vision of the left eye unaccompanied by other symptoms; the vision usually returned to normal within five minutes. Physical exertion often precipitated an attack. Changes of posture were of no importance. No abnormality was found on general physical examination. The blood pressure was 130 mm. Hg systolic and 70 mm. diastolic, and there were no signs of postural hypotension. Ocular examination gave completely negative results. The diastolic pressure in the retinal artery measured 25 mm. Hg in each eye. One day he was examined 30 minutes after an attack; the eyes appeared to be normal, but the retinal artery

TABLE 4

RETINAL ARTERY PRESSURES AMONG PATIENTS WITH INSUFFICIENCY OR THROMBOSIS OF THE CAROTID ARTERY

Location of pressure	Insufficiency (86 cases)	Thrombosis (38 cases)
Pressure lower on side of affected carotid	58	25
Pressure higher on side of affected carotid	5	1
Pressure equal on the two sides	20	7
Not measured	3	5

pressures measured 40 mm. Hg in the right eye and 32 mm. in the left eye.

The patient was asked to remain for observation and about two hours later an attack developed which was observed from its onset. Some 10 seconds after the eye became blind, the pupil of the eye was completely nonreactive to direct light but it reacted consensually when light was thrown into the right eye. Ophthalmoscopically, the retinal vessels of the blind left eye were completely normal in all respects. Pressures in the retinal artery of the right eye were 80 mm. Hg systolic and 22 mm. diastolic, but when the left eye was just barely touched with the ophthalmodynamometer the entire arterial vascular tree was observed to collapse completely. This indicated a systolic and diastolic pressure of approximately zero, since the pressure was too low to register on the instrument. The circulatory system of the eye instantaneously refilled when the pressure was released. Five minutes after onset the vision had recovered completely and pressures in the retinal artery had returned to normal. After Dicumarol therapy was begun, the attacks immediately ceased. Pressures in the retinal artery after 10 days of anticoagulant therapy were recorded as follows: right eye, 70/38; left eye, 60/22.

The identical sequence of events was noted in a patient who, while undergoing neck dissection for a large carcinoma, had a severe spastic contraction of the internal carotid artery brought on by slight traction on the vessel while a piece of tape was being passed around it. The retinal vessels were ophthalmoscopically normal but collapsed when a minute unmeasurable amount of pressure was exerted on the eye. Pressures in the retinal artery returned to normal after the carotid spasm relaxed, and there were no residual visual defects.

Another patient not included in this series had noted transient loss of vision in the lower field of the right eye about once weekly for eight years. While the retinal artery pressure was being measured, the superior retinal arteriole was noted to empty completely of blood for a few minutes. During this time the patient had complete inferior anopsia.

Of the 80 patients who had transient episodes of hemiparesis, facial weakness, hemianesthesia, or aphasia, 42 had concomitant attacks of amaurosis fugax. Ten of these had retinopathy consisting of one to 10 cotton-wool patches scattered sparsely over the perimacular and peripapillary retina. Thirty-three of the 42 had diastolic retinal artery pressure from 20 to 75 percent lower on the affected side. Five had equal pressures on the two sides. One patient who probably had bilateral carotid insufficiency had a higher pressure in the eye on the side causing the symptoms. In three patients the pressure was not measured. Five patients who had hypertensive cardiovascular disease showed an interesting phenomenon in the eye on the side of the compromised carotid artery: the hypertensive arteriolar narrowing and focal constrictions were either absent or less intense than in the opposite eye. All five patients had appreciably lower pressures in the retinal artery on the side of the affected carotid artery.

Thirty-eight patients who had intermittent insufficiency of the carotid artery did not complain of amaurosis fugax. One of these had unilateral retinopathy. Pressures in the retinal artery were lower on the side of the affected carotid artery in 22 patients, equal on the two sides in 12 patients, and higher on the side of the affected vessel in four patients who presumably had bilateral lesions. Three patients, all of whom had lower pressures in the retinal artery on the side of the affected carotid artery, also had fewer and less severe hypertensive arteriolar changes in that eye.

One of the two patients in the group with thrombosis of the carotid artery who had amaurosis fugax complained for four months of this symptom in the left eye and then suddenly right hemiplegia and right homonymous hemianopsia developed; both conditions gradually abated. This patient had a diastolic pressure in the retinal artery of 50 mm. Hg on each side until hemiplegia and hemianopsia appeared; the pressures then changed to 55 mm. Hg in the right eye and 38 mm. in the left eye. After the right homonymous hemianopsia cleared, the pressures in the retinal artery of each eye returned to 50 mm. Hg.

Of the 36 patients who did not have

amaurosis fugax associated with carotid artery thrombosis, four had unilateral retinopathy on the side of the affected carotid artery. Twenty-three patients, of whom seven had angiograms, had a lower pressure in the retinal artery on the side of the thrombosis. In one patient, proved by angiography to have bilaterally occluded carotid arteries, the pressure in the retinal artery was higher in the eye on the side of the cerebral infarction. Seven patients, of whom two had angiograms, had equal pressures in the retinal arteries on the two sides.

Unilateral retinopathy

This interesting phenomenon, which will be discussed later, was encountered in 15 of the 124 cases (table 3). In the literature the occurrence of this phenomenon has been reported when a carotid artery was ligated, but I have not found it described in any reports pertaining to spontaneous thrombosis in the carotid artery. Since retinopathy occurred among 12 percent of the cases in this series, it is difficult to understand why the phenomenon has not been observed before. Reports of two illustrative cases follow:

Case 2

On September 28, 1955, a 55-year-old man reported that he had been having intermittent numbness, tingling, and weakness of the left arm and leg for nearly five years. The attacks lasted for a few minutes and recurred at irregular intervals. The visual acuity and visual fields were normal and he had no ocular symptoms. The results of general and neurologic examinations were normal. Blood pressure was 140 mm. Hg systolic and 80 mm. diastolic. Ophthalmoscopy showed several cotton-wool patches in the right retina but none in the left (fig. 1). The arterioles and veins of the right eye were larger than those of the left eye. Diastolic pressure in the retinal artery was less than 10 mm. Hg in the right eye and was 35 mm. in the left eye. Diagnosis of intermittent insufficiency of the right carotid artery was made. Anticoagulant therapy eradicated his attacks.

Case 3

On March 6, 1957, a 58-year-old man reported that he had had attacks of blurred vision in both eyes two to three times daily for nine months, sometimes accompanied by vertigo and numbness of the left hand and left leg. Examination showed paresis of the left arm and leg and absence of the radial pulses. Pulsation was felt only in one leg. A diagnosis of aortic arch syndrome with occlusion of the subclavian arteries and the right carotid artery was made. He had a cotton-wool patch in the right eye (fig. 2) and pressures in the retinal artery measured 55/30 mm. Hg in the right eye and 95/52 mm. Hg in the left eye.

The retinal findings in the other 13 cases were of similar nature. In all 11 cases of unilateral retinopathy encountered among the 86 cases of intermittent insufficiency of the carotid system, pressures in the retinal artery were much lower on the side of the affected carotid artery. In three of the four cases in which thrombosis was diagnosed the

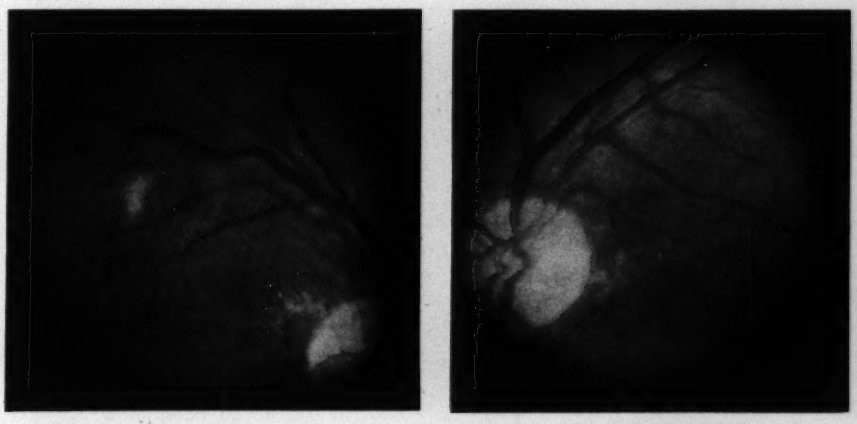


Fig. 1 (Hollenhorst). Case 2. Right eye: cotton-wool patches and dilated vessels. Left eye: normal. Result of insufficiency of internal carotid artery, right side.

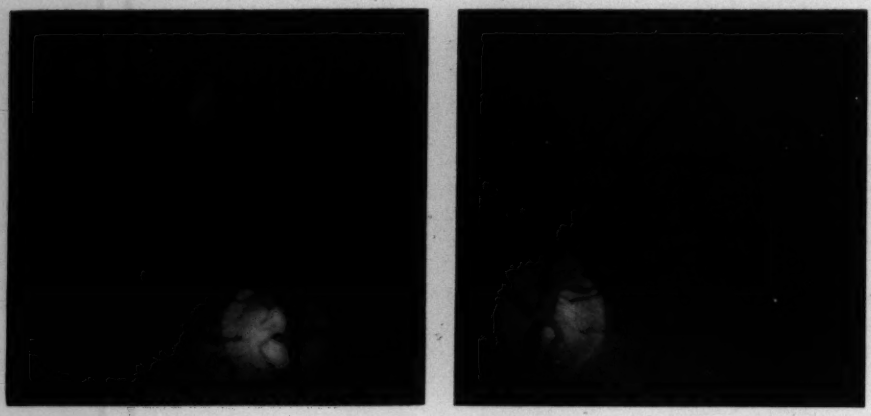


Fig. 2 (Hollenhorst). Case 3. Right eye: cotton-wool patches and dilated vessels. Left eye: normal. Result of thrombosis of internal carotid artery, right side.

pressure was much lower on the affected side; in the fourth case the pressures were equal on the two sides. These low pressures were usually in the range of zero to 10 mm. Hg diastolic, and the pressure on the side of the normal carotid artery might be at any level from 30 to 90 mm. Hg. Mild to moderate hypertensive cardiovascular disease was reported in nine of the 15 cases; in three of the nine, hypertensive retinal arteriolar changes were less severe on the side of the affected carotid artery. Eleven patients gave histories of attacks of amaurosis fugax in the eye with the retinopathy. One patient had arcuate field defects (fig. 3), and another had a small scotoma. A third patient had arcuate field defects in one eye and homonymous hemianopsia to the opposite side (fig. 4), a fourth had slightly incongruous right homonymous hemianopic scotomas (fig. 5), and a fifth had left homonymous hemianopsia which could not be plotted.

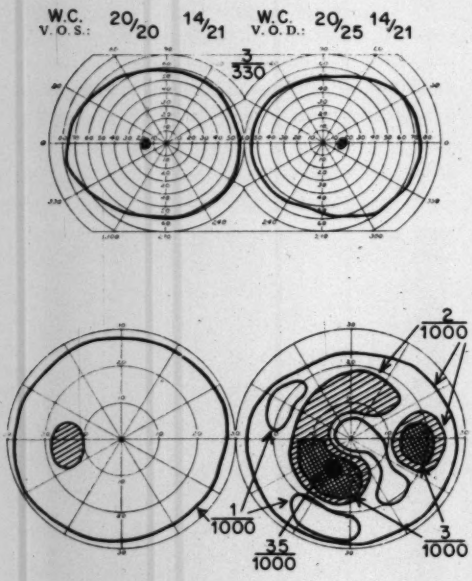


Fig. 3 (Hollenhorst). Right eye: relative and varying field defects. Left eye: normal. Other defects include retinopathy and amaurosis fugax, right eye. Result of insufficiency of internal carotid artery, right side.

Visual defects

The visual defects encountered among these patients were of three kinds: (1) visual loss in the eye on the side of the affected carotid artery only; (2) occlusion of a retinal artery or branch artery on the side of the affected carotid artery and homonymous hemianopsia to the opposite side; and (3) slightly incongruous homonymous hemianopsia.

Eight of the 86 patients who had intermittent insufficiency had occlusions of the central artery or a branch artery and six

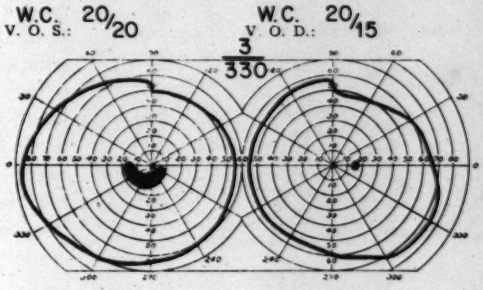


Fig. 4 (Hollenhorst). Right homonymous hemianopsia and arcuate defects in visual field of left eye are results of insufficiency of the internal carotid artery, left side. Other defects include cotton-wool patches in the retina and amaurosis fugax, left eye.

of the 38 patients in whom the carotid artery had thrombosed had such occlusions. Measurements were made of the retinal artery pressure among only eight of the 14 patients; all eight had an appreciably lower pressure on the side of the affected carotid artery. Some of the field defects are shown in Figure 3 and Figures 6 to 9, inclusive.

Four patients among the group of 86 having intermittent insufficiencies and two among the group of 38 having thromboses had occlusion of a central or branch artery associated with homonymous hemianopsia to the opposite side. One of the four had lower pressure in the retinal artery on the affected side. One patient who had bilateral carotid occlusive disease had a higher pressure on the side from which the symptoms arose, two had equal pressures on the two sides, and the remainder were not measured. The field defects are shown in Figures 4 and 10.

Two of the 86 patients having intermittent insufficiencies of the carotid artery experienced transient homonymous hemianopsia. One of the two patients had a higher pressure in the retinal artery on the side of the affected carotid, while the other had equal pressures on the two sides. Two of the group with intermittent attacks had permanent homonymous hemianopsia and both had lower pressures in the retinal artery on the affected side. Among the patients having thrombosis of the carotid artery, two had grossly demonstrable homonymous hemianopsia from which they recovered and both had lowered pressures in the retinal artery on the affected side. Six patients, however, had permanent homonymous hemianopsia. All six had lower pressures in the retinal artery on the side of the thrombosed internal carotid artery. Angiography had been used in two cases; one of the two patients died later. Some of the field defects are shown in Figure 5 and Figures 11 to 13, inclusive.

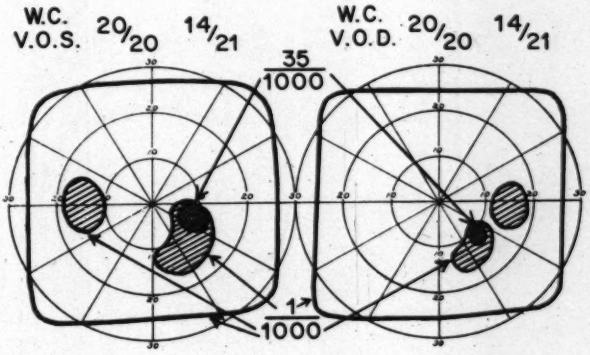


Fig. 5 (Hollenhorst). Incongruous right homonymous lower quadrantanopic scotomas due to infarction in left temporoparietal region in brain. Result of insufficiency of internal carotid artery, left side. Other defects include cotton-wool patches in the retina, left eye.

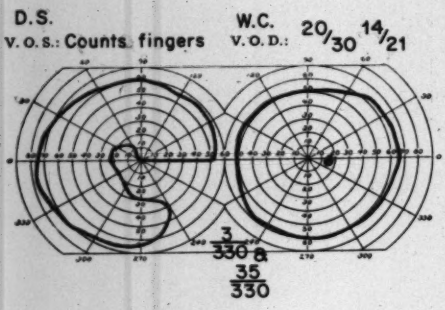


Fig. 6 (Hollenhorst). Left eye: arcuate defects in visual field caused by occlusion of superior temporal arteriole in retina, left eye. Result of thrombosis of internal carotid artery, left side.

Asymmetric hypertensive retinal vascular changes

Eight patients among the group with intermittent insufficiency of the carotid artery and two patients among the group with thrombosis of the carotid artery had lesser retinal arterial hypertensive changes on the side of the affected carotid artery and all of these patients had lowered pressure in the retinal artery on that side (fig. 14).

Papilledema or retinal hemorrhages were not found in any patient. Intraocular pressure was measured in only two patients and was found to be normal in both.

Treatment

Five of the six patients who had amaurosis fugax as their only symptom were placed on anticoagulant therapy and this immediately stopped their attacks. In two the attacks recurred when the therapy was terminated. Of the remaining 80 patients who were having attacks of intermittent insufficiency of the internal carotid artery, 19 were not treated. The condition of only one of the 19 was traced, and his attacks had stopped. Eighteen were advised to have anticoagulant therapy administered by their home physicians; none of these could be traced. In 37 of the 80 patients there was an immediate cessation of the attacks after the administration of anticoagulants was started. Hemiplegia developed in another patient while on this therapy. Three had good results from anticoagulants but hemiplegia developed when use of the drug was stopped. One patient showed improvement when treated with priscoline. The attacks experienced by one patient who had hypotension stopped when ephedrine was used for treatment.

Among the 38 patients who had thrombosis of the internal carotid artery, 25 were not treated, two received anticoagulants but no follow-up study could be made, and six received anticoagulants and had a satisfactory recovery. Five patients who were treated with anticoagulants had poor results and three of this group died.

Comment

The 107 cases of occlusion of the carotid artery collected and reported by Johnson

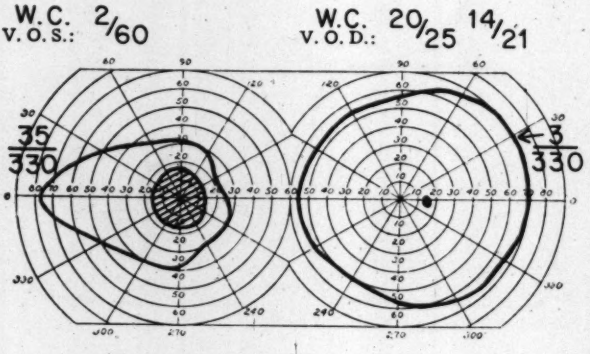


Fig. 7 (Hollenhorst). Left eye: defects in the visual field caused by arterial occlusion in left optic nerve. Result of insufficiency of both internal carotid arteries.

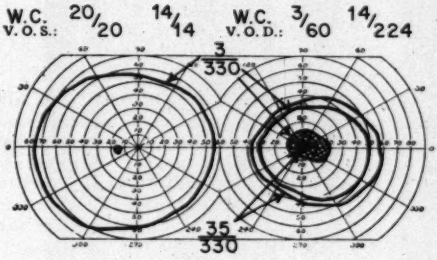
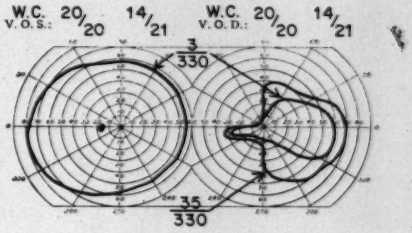


Fig. 8 (Hollenhorst). Right eye: defects in the visual field caused by arterial occlusion in right optic nerve. Result of thrombosis of internal carotid artery, right side.

and Walker[3] constitute the largest series on this condition in the literature. Only 42 of their patients had ocular manifestations. Five had episodes of transient blindness, 11 had optic atrophy, 12 had homonymous hemianopsia, six had diplopia, six had ptosis, two had papilledema, and 14 had pupillary changes (10 of these had a smaller ipsilateral pupil, three had a larger ipsilateral pupil, and one had a fixed ipsilateral pupil). Walsh,[4] Walsh and Smith,[5] and Walsh[6] found homonymous hemianopsia to be the commonest manifestation, but also reported that homolateral blindness often was preceded by transient attacks of visual loss in the same eye. They observed that retinal hemorrhages were reported in only one case in the literature; they did not encounter any cases of papilledema. They had two patients who suffered from homolateral blindness



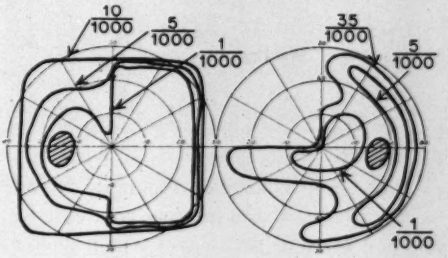


Fig. 10 (Hollenhorst). Defects in visual field of right eye caused by partial occlusion of central artery of right eye, and relative left homonymous hemianopsia, due to ischemia in right temporal lobe. Result of thrombosis of internal carotid artery, right side.

and contralateral loss of the temporal field. One patient had Horner's syndrome and one had ophthalmoplegia associated with concomitant thrombosis of the cavernous sinus. Several patients had transient attacks of homonymous hemianopsia. Of the series reported by Milletti,[7] 28 (58.3 percent) of the 48 patients had ophthalmologic findings: eight had homonymous hemianopsia, two

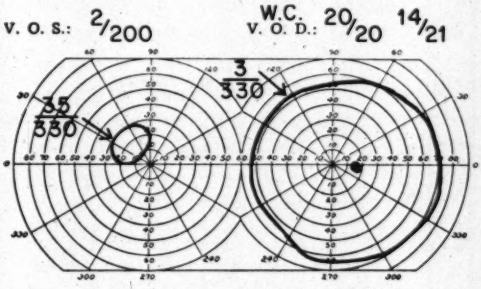


Fig. 9 (Hollenhorst). Left eye: defects in the visual field caused by occlusion of central artery of retina of left eye. Result of insufficiency of internal carotid artery, left side.

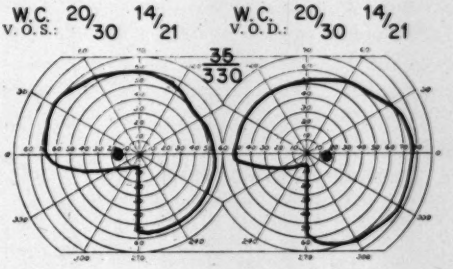


Fig. 11 (Hollenhorst). Slightly incongruous left homonymous lower quadrantanopsia caused by an infarct in temporal lobe, right side. Result of thrombosis of internal carotid artery, right side, proved by angiography.

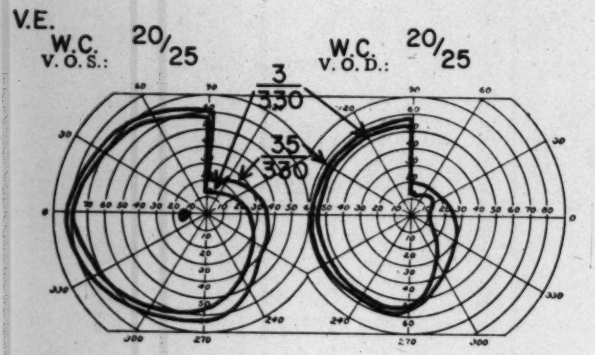


Fig. 12 (Hollenhorst). Slightly incongruous right homonymous hemianopsia, caused by temporo-occipital infarction, left side of brain. Result of thrombosis of internal carotid artery, left side, proved by angiography and at necropsy.

had mild papilledema, and seven had miosis on the side of the affected carotid artery.

Chrást and Gottwald[8] reported 28 cases of thrombosis of the internal carotid artery and two cases of thrombosis of the common carotid artery. Three patients had homonymous hemianopsia, and one of these had transient episodes prior to the onset of the permanent defect. Three had nystagmus and eight had homolateral miosis. Ten percent had papilledema and 16.5 percent had homolateral optic atrophy. Compression of the intact contralateral carotid artery caused retinal ischemia on the side of the thrombosis in three patients. Brégeat[9] mentioned reports of papilledema in this syndrome. Fisher[10] had three cases with a homolateral Horner's syndrome; Krayenbühl and Weber[11] had two cases with a larger homolateral pupil. Webster and collaborators[12] found blindness in only three of 60 cases and homonymous hemianopsia in only four of 60 cases. Sugar, Webster, and Gurdjian,[13] and King and Langworthy[14] also discussed the ocular manifestations. Golowin[15] reported that ligation of the carotid artery caused a decrease in the intraocular pressure of 2.0 to 3.5 mm. Hg, but Elschnig stated he could not confirm this in his own cases. Chrást and Gottwald[8] mentioned that five of 15 patients had a lower intraocular pressure on the affected side.

Ophthalmodynamometry

Measurement of the pressure in the retinal arteries with the ophthalmodynamometer has received scant attention in the American literature until quite recently. Probably the first investigator to call attention to the lowering of pressure in the retinal artery on the side of an occluded internal carotid artery was Baurmann[16] in 1936. He also noted that the pressure in the contralateral retinal artery increased under the

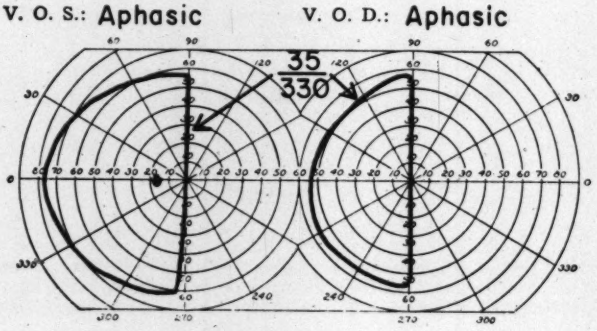


Fig. 13 (Hollenhorst). Complete right homonymous hemianopsia, caused by infarction of left side of brain. Result of thrombosis of internal carotid artery, left side, verified by angiography.

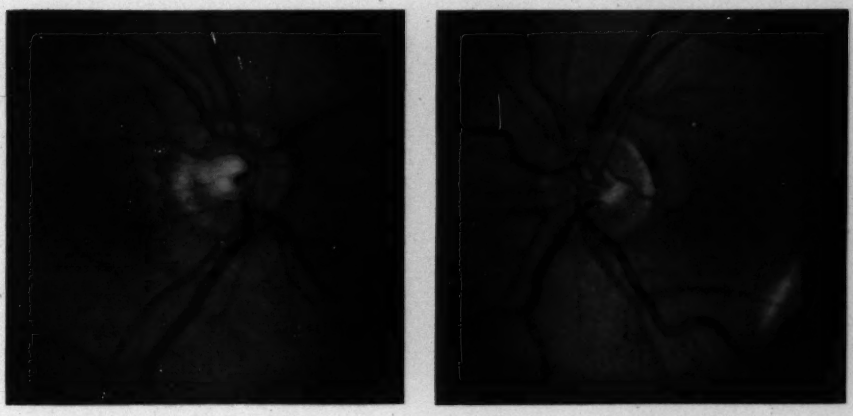


Fig. 14 (Hollenhorst). Right eye: arterioles of retina narrowed, mildly sclerotic, and irregular. Left eye: arterioles larger than normal and regular in caliber. Result of insufficiency of internal carotid artery, left side.

same circumstances. However, this phenomenon remained essentially unknown in the United States.

Koch[17-19] wrote three excellent articles in which the ophthalmodynamometer was mentioned, but apparently he was unaware of the effects of carotid occlusion on the retinal artery pressure. In 1944 Trotot[20] reported the case of a patient who had internal carotid thrombosis, right homonymous hemianopsia, and lower pressure in the retinal artery of the left eye. Krayenbühl[21] measured pressures in the two retinal arteries in only two of his 25 patients and found them to be equal. Milletti[7,22] alone and later with di Luca[23] wrote several articles on the subject of ophthalmodynamometry. Johnson and Walker[3] mentioned the retinal artery pressures in seven cases which they collected from the literature: in four the pressures were equal on the two sides, in two the pressure was lower on the side of the occluded carotid artery, and in one no comparison of the two sides was made. Since then, a large number of articles on this subject have appeared in the literature.[24-37]

The data presented in my series of 124 patients validate these measurements as a valuable tool for diagnosis. By means of intra-arterial pressure measurements Bakay and Sweet[38] showed that when the internal carotid artery is occluded the percentage drop is the same in all portions of the internal carotid artery distribution and its accessible branches. Some of the arteries they measured were only 0.4 mm. in diameter. They found that ligation of the cervical carotid artery usually lowered the arterial pressure by about 50 percent. These are approximately the same figures reported by means of ophthalmodynamometry in the papers of Hollenhorst, Wilbur, and Svien[34] and of Blodi and Van Allen.[35]

Controls numbering into the thousands have been measured by the author and by others in the literature, and a remarkably equal pressure level has been noted in the two retinal arteries of normal persons. Consequently, a variation of 5.0 mm. for pressures below 50 mm. Hg and a variation of 10 mm. for pressures above 50 mm. has been used as a measure of significant difference in the diastolic pressures between the two sides. In practice, the differences are usually much greater than this. Usually the pressure on the occluded side is from 25 to 50 percent of the pressure recorded on the normal side. A lower pressure on one side therefore has considerable significance in indicating a disturbance of the carotid artery

circulation on the side of the lower pressure. If the pressures are equal on the two sides, occlusion of the carotid artery is not ruled out, since collateral circulation may serve to maintain the pressure in the retinal artery on the side of the occluded carotid artery. In some cases the pressure has been found to be higher on the side of the suspected carotid occlusion. In this event the patient probably has bilateral occlusion of the carotid arteries, but with only unilateral symptoms. One such case in this series was proved by angiography.

Visual disturbance

Loss or impairment of vision resulting from thrombosis of the internal carotid artery or of its branches may be of several types: (1) occlusion of a branch of the central artery of the retina will cause arcuate field defects; (2) occlusion of the central artery or of the ophthalmic artery will cause total or almost total blindness in one eye; (3) occlusion of the middle cerebral artery or one of its branches will produce homonymous hemianopsia of slightly incongruous type characteristic of lesions of the optic radiations in the temporal lobe; and (4) occlusion of a branch of the central artery, or of the central artery, or of the ophthalmic artery with simultaneous involvement of the middle cerebral artery will produce blindness or partial blindness in the eye on the side of the abnormal internal carotid artery and a loss of vision in the temporal field of the opposite eye.

Among patients who have intermittent insufficiency of one or several of these vessels, there may be transient attacks of loss of vision in one eye or transient homonymous hemianopsia lasting usually only a few minutes. Such attacks may vary in frequency from 10 to 12 daily to attacks several months apart.

The term "amaurosis fugax" is applied to transient losses of vision which occur in one eye only. The obscuration of vision may be either partial or complete; it usually occurs without warning, reaches its maximum in a few seconds, and is followed in the next five minutes or so by a gradual return to normal. Wagener[39] discussed this problem thoroughly. This symptom was present among five of the 107 cases collected by Johnson and Walker.[3] Fisher[40] reported seven cases in which amaurosis fugax was associated with hemiplegia, all probably due to occlusion of the internal carotid artery. He considered this a vasospastic phenomenon, but admitted the inadequacy of this as the sole explanation. He also called attention to those patients who have amaurosis fugax and who get relief from this symptom without visual loss when hemiplegia occurs.[41]

There are a few descriptions in the literature in which the fundus was observed during the attack of transient visual loss. Lindenberg and Spatz[42] reported the case of a patient whose retinal vessels gradually became "snow-white" and then as redness reappeared the vision returned. In one branch of the retinal artery the blood flowed backward. Foerster and Guttmann's[43] patient suffered repeated attacks of blindness in the right eye. One attack occurred under ophthalmoscopic examination, and vision was lost first in the lower field. The vessels running to the upper part of the retina became bloodless. Elschnig[44] did not observe any change in the appearance of the retina when the internal carotid artery was ligated. The three instances reported in this paper in which ophthalmoscopic examination was carried out during an attack show that various phenomena occur.

With regard to homonymous hemianopsia, Walsh[6] stated that often there was a relative sparing of the upper quadrants of the defective half fields, which he ascribed to the fact that the superior portion of the optic radiations is supplied by the middle cerebral artery and the lower portion by the posterior cerebral artery. The findings in the present series support this statement.

Two phenomena were observed in this series of patients which have not before been reported in the literature on spontaneous thrombosis or insufficiency of the internal carotid artery, although there are references to the phenomena having been observed among patients who had ligation of one internal carotid artery. The first of these manifestations is the appearance of cotton-wool patches in the retina of the eye homolateral to the lesion in the internal carotid artery. A search of the literature revealed two recent reports of this type of retinopathy. Swan and Raaf[45] described five patients whose common and external carotid arteries were ligated for treatment of a carotid-cavernous sinus communication and one patient who had ligation of the internal carotid artery only. Hypotonia occurred and lasted three to six weeks. The arterioles narrowed but the venules widened. In three of these patients cotton-wool patches developed after 80 to 90 hours, increased in size and number for eight to 10 days, and cleared up three or four weeks later.

Schenk[46] encountered two similar cases and found reports of four more in the literature. He called this "traumatic retinopathy of Purtscher" and ascribed it to stasis in the retinal veins and to serum transudation into the retina. The mechanism of production of the retinopathy is unknown. However, the finding in this series of a much lower retinal artery pressure in the eye containing the retinopathy among 14 of the 15 patients strongly suggests that the cotton-wool patches are in fact ischemic infarcts in the nerve fiber layer of the retina produced by hypotension.

The phenomenon of lessening the hypertensive arteriolar narrowing and the disappearance of focal constrictions on the side of the occluded internal carotid artery was described by Kirby and Hollenhorst[47] in two patients who had ligation of these vessels for treatment of an intracranial aneurysm. This too appears to be a result of lowered retinal arterial pressure, as all 10 of the patients who had this finding were shown to have lowered pressure on the affected side.

Summary

The ocular manifestations of 124 patients who had insufficiency or thrombosis of the carotid artery system were investigated and reported. The diagnosis was made either clinically or by angiography.

The major symptom among the group of 86 patients who had intermittent insufficiency of the internal carotid artery was that of amaurosis fugax, which was present among 48, and which was cured in most instances by anticoagulant therapy.

Other ocular manifestations included retinopathy on the side of the affected carotid artery in 15 of the 124 patients, asymmetric hypertensive retinal vascular changes in 10 patients, and lowering of the pressure in the retinal artery on the side of the affected carotid artery among 83 patients. Occlusions of the retinal artery or branch artery were discovered among 14 patients and six more had an associated homonymous hemianopsia to the opposite side. Three patients had hallucinations in the homonymous half fields; three others had transient homonymous hemianopsia, and eight had permanent homonymous hemianopsia.

The importance of establishing the diagnosis of carotid occlusive disease during the period of intermittent insufficiency is stressed. Ocular symptoms which point to impending carotid occlusion include episodes of transient or permanent diminution of vision in one or both eyes. Such signs as a lowered pressure in the retinal artery of one eye, cotton-wool patches in one eye, or asymmetric hypertensive changes should alert the examiner to the possibility of carotid artery disease.

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SERIOUS VISUAL TROUBLES CAUSED BY UNUSUAL CIRCULATORY DISTURBANCES IN THE REGION OF THE OPTIC NERVE*

JOSEPH IGERSHEIMER, M.D.
Boston, Massachusetts

What I wish to discuss today are cases with serious visual difficulties which are not explained by changes in the retina but are caused by pathologic alterations in the optic nerve. They have nothing to do with the demyelinating disease of the nerve and there is not the picture of an obstruction of the central retinal vessels, nor are there signs of a pressure upon the nerve by a sclerotic artery or an aneurysm. There are, nevertheless, enough clinical facts which show that the circulatory system is an important etiologic factor. Very helpful for our knowledge would be a miscroscopic examination. Unfortunately there exist only a very few such reports. Every one of them is, therefore, of a certain value. I will make it a special point to acquaint you with those histopathologic reports which have already been published, although they may not explain fully the whole pathogenesis.

LESIONS OF THE NUTRITIVE VESSELS IN THE OPTIC NERVE

In 1924 Uhthoff[1] described three elderly patients who experienced a sudden total or almost total loss of vision in one or both eyes, with a blurry, somewhat edematous disc and great visual field defects. The retinal

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arteries were narrow in one of his cases, and there were some hemorrhages around the disc. In an amazingly short time the ophthalmoscopic picture changed to a well-bordered optic atrophy. In all his cases the blood pressure was high and the arteriosclerosis marked. Uhthoff thought disturbances were in the vessels which were responsible for the nutrition of the optic nerve and retina. Other clinical reports confirmed Uhthoff's observation. Beselin[2] believed the disturbance to be at the distal end of the optic nerve. François and associates[3] also point to the same disturbances.

A few years later I had the opportunity to examine a rather similar case clinically and anatomically (Igersheimer[4, 4a]) of a 49-year-old hypertensive patient. From the publication one can see that there was an arteriolosclerosis in the brain as well as in inner organs and, since the central retinal vessels were intact, I concluded that the cause of the optic nerve degeneration probably lay in pathologic changes in the small vessels. Because of the fixation procedures for the histologic examination I was not able to use fat-staining and could, therefore, not really prove my point.

This assumption received some support from another anatomic examination. The 76-year-old patient of v. Stief[5] was totally amaurotic for four years. The vessels in the cerebrum showed progressive arteriosclerosis and there were malacia spots in different regions of the brain but not near the optic nerve, chiasm, or optic tract. No aneurysms and no pressure effects from a sclerotic ophthalmic artery could be found. The small vessels in the optic nerve, however, were thickened and very narrow, although apparently not totally closed. Stief had no other explanation for the loss of vision and the degeneration of the nerve than the condition of the small vessels. The myelin sheath of the nerve fibers had totally disappeared and the axis cylinders had been greatly damaged.

The question is whether it is possible that a total degeneration in the nerve takes place when a great number of the small nutritive vessels do not function. No clear-cut answer is, as yet, possible. More studies about nutrition of the nerve are necessary. According to the newest investigations of François and Neetens[6] there is in addition to the central retinal artery, which has nothing to do with the nutrition of the optic nerve, a central optic nerve artery. This central optic nerve artery is given off by the ophthalmic artery and divides in the middle of the nerve into an anterior and a posterior branch; it forms the axial nutritional system of the optic nerve in its intraorbital and intracanalicular part. Anastomoses exist between the capillaries of the circle of Zinn and the ramifications of the anterior branch of the optic nerve central artery. Other capillaries issue from anastomoses between the extraorbital cerebral vessels which run into the pial sheath and help to feed the optic nerve. Steele and Blunt,[7] however, could in no instance detect a direct arterial anastomosis between the central retinal artery and vessels derived from the circle of Zinn. It is still controversial whether anastomoses exist between the axial and peripheral vascular system in the optic nerve. Rintelen (1946) found in a certain number of optic nerves of people, who had died of arteriosclerosis or general hypertension, severe changes in the optic nerves due to sclerosis of vessels. He thinks that arteriosclerotic optic atrophy is the most frequent kind of optic atrophy. In several cases he saw localized scars in the nerve tissue, usually not far behind the globe, and, in one case, he found a softening, a real apoplexy, but he did not give any details. Rintelen,[8] as well as former investigators (E. Fuchs[9]), stated that the occlusion of small vessels will cause circumscribed lesions in the optic nerve tissue. This is the difficulty in explaining total degeneration of the optic nerve by the pathologic changes in the small vessels, as in my cases and those of v. Stief already mentioned.

The whole topic of vascular changes within the optic nerve received new impetus when temporal arteritis was described as a new

disease by Horton, Magath, and Brown.[10] In the Mayo Clinic alone 105 cases of temporal arteritis were observed between 1931 and 1951 (Benedict, Wagener, and Horton[11]). Among the ocular lesions in temporal arteritis there is one important group which has a course and signs quite similar to the aforementioned cases of Uhthoff. The patients are usually elderly, with arteriosclerosis and often general hypertension, who suffer sudden loss of vision in one or both eyes, with central scotoma which cannot be explained by changes in the retina or the central retinal vessels. The idea of a direct relationship between the diseased temporal artery and the ocular pathology was discarded early.

There is no doubt that in this group the pathology is vascular in character and seems to be, in most cases, located in the distant part of the optic nerve. In favor of this location are the following clinical factors:

1. The paleness of the edematous disc at the onset, which was therefore called ischemic by different authors (Wagener,[13] Bruce,[14] Bessière and Julien,[15] Siegert,[16] and others).

2. Some venous congestion and small hemorrhages are present on the disc.

3. Occasionally a segregated blood column is seen in the retinal vessels (Kurz,[16a] Burk[16b]).

The only histologically examined case was described by Kreibig.[17] The visual loss in his 69-year-old patient had started only two weeks before the anatomic examination could be performed. Just behind the lamina cribrosa there was a 1.5-mm. large necrotic focus surrounded by mononuclear cells. Myelin staining of optic nerve fibers was still partly possible. The central retinal artery, as well as the retina, showed no pathology.

As interesting and important as this observation is, I think Kreibig was not justified in assuming that all clinical cases of this group are due to a malacia in the optic nerve. At least it is not proved. The vascular origin, however, is not debatable.

Of special interest in Kreibig's case is the fact that the ophthalmic artery showed a severe panarteritis with granulomatous formations in the vessel wall and intima proliferation; the lumen of the artery was in some parts totally occluded. There were also pathologic changes in the vessels of the circle of Zinn and the very small vessels which passed the meninges on their way to the optic nerve.

The question arises what the severe pathology of the ophthalmic artery and of the small vessels had to do with the great visual loss. As yet, it is believed that an obstruction of the ophthalmica is responsible for visual disturbances only if a thrombus extends into the central retinal artery. In this case the central retinal artery was, however, normal from the beginning to the end. Inflammatory changes in the optic nerve were negligible.

In another case published by Heptinstall, Porter, and Barkley[18] both ophthalmic arteries showed giant-cell arteritis but, in spite of blindness, no evidence of optic atrophy could be found. This is difficult to understand.

By surveying a series of cases with more or less extreme visual loss, cases with and without temporal arteritis, it is evident that often the vascular pathology does not affect the central retinal vessels. It is to be hoped that more histologic findings will solve some still pending problems. To avoid misunderstanding, I want to stress the point that in a number of other cases—especially in the literature about temporal arteritis—the central retinal vessels were visibly involved and probably the cause of the visual loss.

Intracanalicular edema of the optic nerve

The next group I want to discuss briefly was, as far as I can see, described only in French articles (Bregéat and David,[19] Renard, David, and Bregéat,[20] David, Bregéat, and Taleirach,[21] Paillas, Guillot, and Duplay,[22] Gros and Caraban,[23] Terracol and Gros,[24] Bregéat.[25]).

Bregéat, the ophthalmologist, and David, the neurosurgeon, observed (1948) the first case of this series. It was operated under the

diagnosis of an opticochiasmatic arachnoiditis. However, during the operation signs of an opticochiasmatic arachnoiditis could not be found. Instead there was a tremendous edematous swelling of the intracanalicular optic nerve.

According to the experiences of different French authors there exists an acute and a subacute stage of this disease. The acute cases are rare and occur suddenly in young adults. They are usually bilateral and progress rapidly to total blindness. In the first days there is a large cecocentral scotoma, and often a defect in the lower part of the visual field; at the same time there is a marked papilledema with some hemorrhages near the disc and some congestion of the retinal veins. Otherwise the patient feels good, and the neurologic status is normal.

The whole condition is caused by a strangulation of the swollen optic nerve in the optic canal, and is almost immediately relieved by an incision in the sheath of the nerve and a partial resection of the roof of the optic canal. Also in the subacute cases the edema and the strangulation of the nerve are the main pathologic findings. The clinical course is slower. It starts with a certain diminution of vision and central scotoma, while the disc still appears normal in the first days and gets blurry somewhat later. The interval between affection of the first and second eyes can be several weeks or months. The neurosurgical condition is similar to the one in acute cases but the surgical results vary—very satisfactory, moderate, or negative. The condition may be complicated by a meningoencephalitic pathology. Without this complication the status of the nervous system, of the lumbar fluid, and nasal sinuses shows no abnormality.

The pathogenesis of this condition is still somewhat obscure. Since quite a number of cases responded very well to antibiotic treatment, an inflammatory infectious etiology is contemplated. The French authors, however, warn not to postpone surgical intervention more than four to five days or at most a week, if there is not rapid improvement.

I have never seen such a case and found no article in the Anglo-American literature concerning this disease.

I mentioned this condition here because it is likely that the circulatory system in the optic nerve is involved and because the autopsy in vivo (that is, the surgery) uncovered such an interesting condition of the optic nerve.

Marked inflammation of the retrobulbar optic nerve involving the central vessels

The last group of this paper is represented by one case but this case deserves more than casual interest.

Case report

Richard T., aged 24 years, was admitted to the neurologic service of the New England Center Hospital (Dr. John Sullivan, director) on November 16, 1955, and October 29, 1956, because of different, slight, and temporary neurologic disturbances (general fatigue, decrease of sensation, and weakness of the right leg, later on of the left leg). The reflexes were brisk. Lumbar fluid in 1955: five lymphocytes, protein 70 mg. percent, 61 mg. percent glucose; in 1956: 50 lymphocytes, protein 80 mg. percent, glucose 81 mg. percent. A mild case of anterior poliomyelitis was considered but the diagnosis was uncertain.

At the third admission on March 13, 1957, he entered the hospital with the complaint of blurring of the right eye which started two days before. During the night of March 11th, there was a sudden clouding of vision in the right eye which disappeared in about five minutes. The next day the clouding occurred about eight different times, each episode lasting 15 minutes. During each episode he could see only forms of objects without any detail. About three days before the onset of the visual troubles he developed frontal headaches and a sharp pain in the right eye. An eye examination at that time showed that the right pupil reacted to direct light but better to indirect light. There was a marked blurring of the right disc with some hemorrhages and dilated veins. There was a large central scotoma in the right eye and the diagnosis was optic neuritis. The left eye was normal, showing only slight blurring of the disc.

Now the tentative diagnosis was a demyelinating disease because of the ocular findings and some slight reflex changes.

I first saw this patient on April 2, 1957. There was hypermetropia of both eyes and convergent strabismus of the right eye. This strabismus, as

well as a certain amblyopia, had been present for many years.

Vision of the right eye was (with glasses), 10/200 and of the left eye, 10/10.

There was still a paracentral scotoma between the fixation point and the blindspot and some constriction temporally and downward. With a 10-mm. red test object, the whole temporal lower quadrant was absent, including the fixation point.

Fundus. The borders of the discs in both eyes were blurred without prominence. There was, however, a definite difference between the discs, as the arteries and veins on the right disc were smaller and there were in addition fine hemorrhages and slight disturbances (tortuosities) in some of the vessels on the disc. The left eye showed what seemed to be pseudoneuritis.

I had the impression that this was not a papillitis as one sees it in a demyelinating disease but that there was some vascular disturbance in the optic nerve behind the globe. Because of the pain in moving the right eye, an inflammatory factor seemed also to be present. Sooner than I expected, the vascular character of the disease became evident.

On May 17th—that is about six weeks later—the condition was still about the same, but on May 20th the right eye suddenly lost all vision and the pupil was fixed to light. The swelling of the disc was somewhat increased (to three diopters); there were some new hemorrhages on the disc and also some exudates around the disc. The blindness of the eye could not be explained by the fundus picture. Lumbar puncture, exploration of the sinus, and X-ray studies were all negative.

During the next few weeks many retinal hemorrhages developed, almost like an obstruction of the central vein, and a very unusual, beautiful neoformation of fine vessels covered the disc, a kind of rete mirabile. There was considerable secondary involvement of the retina. The disc itself could no longer be recognized. There was not one normal vessel starting from the disc, and it was impossible to differentiate arteries and veins. The vessels changed to white bands. Also worth mentioning is a definite iris hyperemia, a picture similar to that of diabetic rubeosis.

On August 5th the right eye was enucleated in the Massachusetts Eye and Ear Infirmary because of threatening glaucoma. Histologically (Dr. David Cogan) the central retinal artery showed definite changes in its outer and inner wall, and the central retinal vein was blocked, as well as surrounded by cellular infiltration.

Comment

This case is especially interesting because at one time demyelination seemed to be justified as a diagnosis but the clinical course as well as the anatomic examination proved that the ocular disease had a vascular basis.

At the last clinical examination on May 1, 1958, the patient was in good shape. Once in a while his back and legs ache and he gets tired, but only for a few hours after standing up. The left eye did not show any change.

483 Beacon Street (15).

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EVALUATION OF VIABILITY OF PRESERVED RABBIT CORNEAS BY TISSUE CULTURE PROCEDURES*

F. W. Stocker, M.D., A. Eiring, M.S., R. Georgiade, M.A., and N. Georgiade, M.D.
Durham, North Carolina

An increase in corneal grafting operations has produced a greater need for donor material. In order to utilize the available tissue to the best effect, a satisfactory method of storing donor material over a prolonged period of time is necessary. Tissue banks, which are able to keep a variety of body tissues such as bone, cartilage, and arteries for prolonged periods of time, have been established in many parts of the country and have been very successful. Banks for the preservation of corneas have not been equally successful. The method generally employed by eye-banks is to store donor eyes in a moist chamber at +4°C. Most corneal surgeons are reluctant to use corneas which have been stored in this manner for longer than 48 hours. This leads to a waste of precious tissue.

The following methods of preservation have been employed by various investigators in attempts to obtain clear corneal grafts: (a) formalin fixation,[1] (b) drying,[2] (c) freezing,[3] and (d) freezing-drying.[4, 5] These methods have not been satisfactory.

Three methods have evolved which appear to be more promising. These are: (a) storage in liquid paraffin (mineral oil),[6] (b) vacuum dehydration,[7] and (c) freezing after glycerol treatment.[8]

Numerous British and European authors have reported excellent clinical results with corneas stored in liquid paraffin at +4°C. Bürki, who first described this method,[6] summarized his experimental studies and clinical experience with perforating grafts in a comprehensive monograph.[9] In a comparative study, he reported 10 clear grafts out of 23 (43.5 percent) with corneas preserved in a

* From the Duke University School of Medicine: the Department of Surgery, the Plastic Surgery Research Laboratory, and the Division of Ophthalmology. This work was aided by U. S. Public Health Grant B-1161, and by Playtex Park Research Institute Grant TR65. Presented in part at the 94th annual meeting of the American Ophthalmological Society, May 30, 1958, at White Sulphur Springs, West Virginia.

moist chamber at +4°C., while a group of 46 cases which were grafted with corneas preserved under mineral oil had 24 (52.2 percent) clear grafts. In general he used the donor cornea within a few hours, but has obtained clear grafts with material stored for several days. Rycroft[10] reported successful operations with the donor eye having been stored in mineral oil at +4°C. for as long as two weeks.

The second method of preservation which has appeared promising is that of vacuum dehydration. This method has been quite satisfactory for lamellar grafts.[7] Reports on results of perforating grafts with material preserved this way are incomplete. King† feels that there is not enough evidence at this time to advise the use of these corneas for penetrating grafts.

The third method of promise is that of glycerol treatment followed by storage at subzero temperatures. Very satisfactory clinical results with lamellar grafts have been reported with this method. Also clear penetrating grafts were obtained in some cases with material preserved in this manner by Eastcott.[8] The over-all results, however, were not good enough for the author to recommend this procedure for full-thickness grafts.

It has been shown that it is not necessary for the corneal tissue to be in a demonstrably viable state for successful lamellar grafts. Various observations, which shall be discussed later, suggest that it may be very important for the endothelium of the donor eye to be in a viable state at the time of transplantation in the case of perforating grafts. In vitro methods which demonstrate the viability of the tissues are valuable. These methods include: (a) electrophoretic studies of the proteins of the cornea,[11] (b) grafting of corneas onto the chorioallantoic membrane of 10-day-old chick embryonated eggs,[12] (c) measurement of oxygen uptake,[13] and (d) tissue culture studies.[14] Positive tissue cultures would indicate that the tissue is viable, but a negative result would not definitely preclude the possibility of obtaining a living graft in vivo. Persistent negative results would cast severe doubts on the viability of the tissue examined.

McPherson, et al.,[15] and Draheim, et al.,[14] used tissue culture techniques successfully in determining viability of preserved corneal tissue. Fresh rabbit corneas showed excellent migration of epithelial and fibroblastic cells in all instances within 48 hours. Corneas which were soaked in dilute glycerol or soaked and then frozen at −79°C., showed a slight lag in migration but were soon indistinguishable in migration and cell appearence from fresh corneas. It was found that storage of the glycerol-frozen corneas for longer than one month resulted in changes in the physical appearance and decreased viability of the tissue.

In all of the above-mentioned methods for demonstrating tissue viability little is said about which portion of the corneal tissue, that is, epithelium, stroma, or endothelium, actually had survived the preservation and storage treatment. The question why lamellar grafts were uniformly successful with glycerol frozen material in contrast to perforating grafts was not answered by these investigations. It might be possible that the corneal epithelium and stroma would survive the freezing process, but the delicate endothelium would be more severely damaged which would result in unsucessful perforating grafts. An experimental method to demonstrate the viability of each of the three corneal tissues after preservation would be very helpful in the development of the optimal technique for successful viable corneal preservation.

Materials and Methods

The technique developed in this laboratory for separating corneas into three layers and culturing them separately in vitro has been described elsewhere.[16] Briefly summarizing those results, the epithelial and endothelial cells commence migration and proliferation

† Personal communication, July 7, 1958.

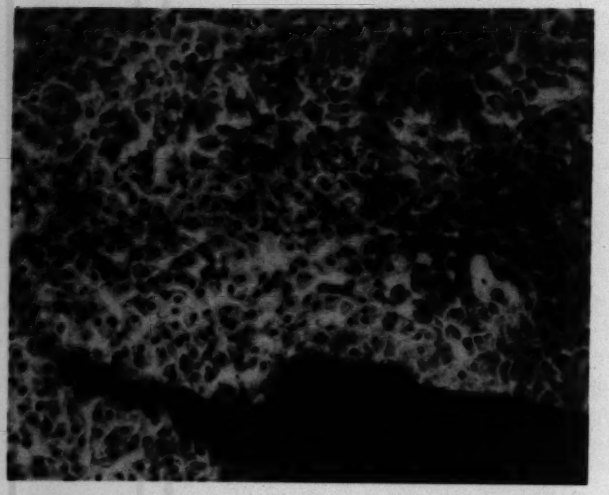

Fig. 1 (Stocker, et al.). Epithelial cells from rabbit's cornea growing in tissue culture after seven days (×140).

in one or two days and have a good outgrowth in three to five days. In contrast, the stromal cells have a lag period of three to five days before migration and proliferation commence. Figure 1 shows the outgrowth from a seven-day culture of the epithelium; Figure 2 is of a 10-day culture of the stromal layer; and Figure 3 shows endothelial outgrowth in a seven-day culture.

After development of this technique, experiments were performed to determine the effects of the three most promising preservation methods (mineral oil at +4°C., vacuum dehydration, and glycerol-freezing) on the individual layers of rabbit corneas.

Adult rabbits were killed by inoculation of sodium pentobarbital into the marginal ear vein, and the corneas were immediately removed under aseptic conditions. Usually a narrow ring of scleral tissue was left attached to the cornea. The excised corneas were placed in a sterile beaker containing Hanks' balanced salt solution[17] without sodium bicarbonate (RBSS). After soaking three to five minutes, the corneas were transferred to either screw-capped tubes contain-

Fig. 2 (Stocker, et al.). Stromal cells from rabbit's cornea growing in tissue culture after 10 days (×80).

ing five ml. of preservative fluid or to rubber stoppered tubes containing four ml. of sterile liquid paraffin (mineral oil). Each tube received only one cornea. The screw-capped tubes were taped with adhesive tape and coated with melted paraffin. After soaking for approximately one hour at room temperature, the mineral oil tubes were placed at +4°C., and the tubes containing preservative fluid were placed at one of the following temperatures: −45°C. (mechanical); −79°C. (dry ice); or −196°C. (liquid nitrogen). Step-wise freezing was not done. At various intervals of time a tube was removed, thawed in a 37°C. water bath, and the preservative fluid removed. After rinsing two times with RBSS, the cornea was transferred to a small petri plate and the scleral tissue removed. The cornea was separated into three parts and explants prepared as previously described.[16]

Preservative fluids employed were composed of either ethylene glycol or glycerol in concentrations of 1.0, 5.0, 10, 15, 20, 25, 30, 50, 75, 90, or 100 percent. Either RBSS or oxypolygelatin (OPG) was used as diluent.

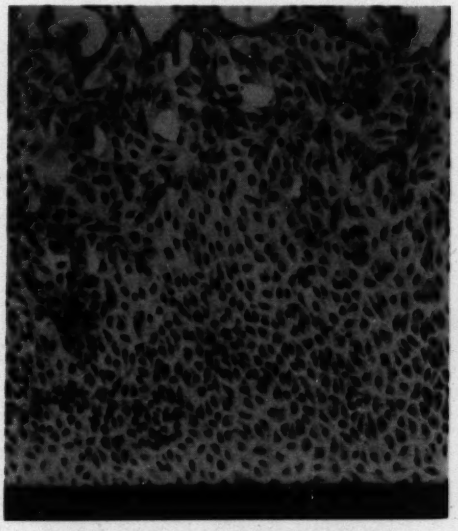

Fig. 3 (Stocker, et al.). Endothelium of rabbit's cornea after seven days in tissue culture. Definite growth of endothelial cells is observed (×88).

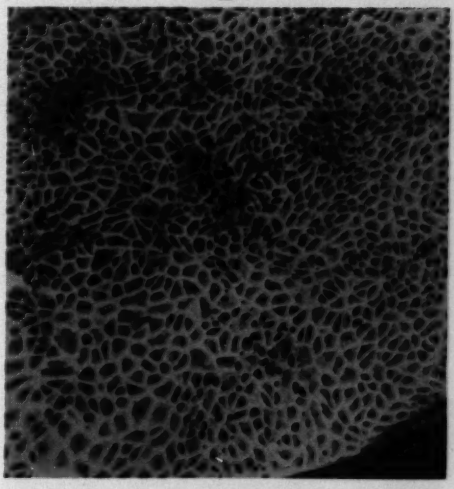

Fig. 4 (Stocker, et al.). Endothelium of rabbit's cornea which had been stored in mineral oil at +4°C. for four weeks shows abundant growth after 10 days in tissue culture (×80).

Sterilization of mineral oil was by dry heat sterilization. The preservative fluids were sterilized by autoclaving.

Results

Corneas were stored in mineral oil at +4°C. for varying intervals of time. After one week of storage, all three layers showed excellent growth. The experiments were extended to 2, 3, 4, 5, 6, 8, 10, and 12 weeks of storage. Positive cultures were obtained from all three layers for as long as five weeks' storage. Figure 4 shows abundant growth of the endothelium after four weeks' storage. After six weeks' storage, no growth occurred from any of the three layers. Upon gross observation, corneas which were stored up to five weeks were clear when removed from storage, whereas corneas which had been stored for six weeks or longer were cloudy. From these observations, it may be concluded that all three layers of the cornea remain viable for approximately five weeks when stored in mineral oil at +4°C.

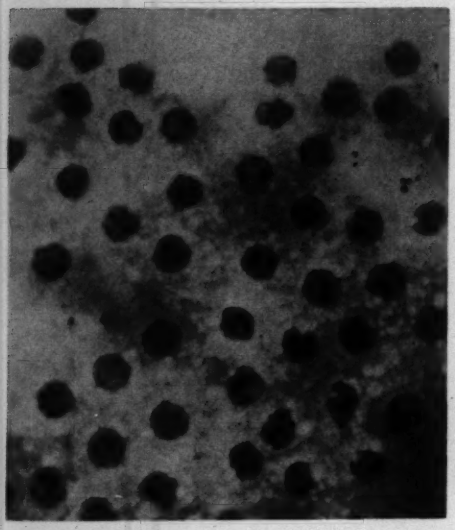

Fig. 5 (Stocker, et al.). Fixed flat preparation of human corneal endothelium after 48 hours of storage in moist chamber at +4°C. The endothelial layer is not continuous any more. Extensive vacuolization of cytoplasm and nuclei is present (×678). From Stocker.[38]

Fig. 6 (Stocker, et al.). Fixed flat preparation of human corneal endothelium after four weeks' storage in mineral oil at +4°C. The picture is roughly comparable with that presented in Figure 5 (×300).

It is interesting to compare the morphologic appearance of the endothelium of human cornea after storage in moist chamber at +4°C. and in mineral oil at +4°C. Figure 5 shows the endothelium in a flat preparation (technique previously described[18]) after 48 hours of storage in moist chamber. In Figure 6 the endothelium is seen as it appears after four weeks' storage in mineral oil. In general, the appearance is comparable, that is, there is a continuous sheet of endothelial cells, somewhat loosened in some areas with vacuolization of the cells. In contrast, after four days of storage in a moist chamber, the endothelial layer is completely disrupted with large parts of Descemet's membrane being denuded as shown in Figure 7.

The second method of promise is that of vacuum dehydration, Through the courtesy of Dr. King we were able to extend our investigations to corneas which had been de-

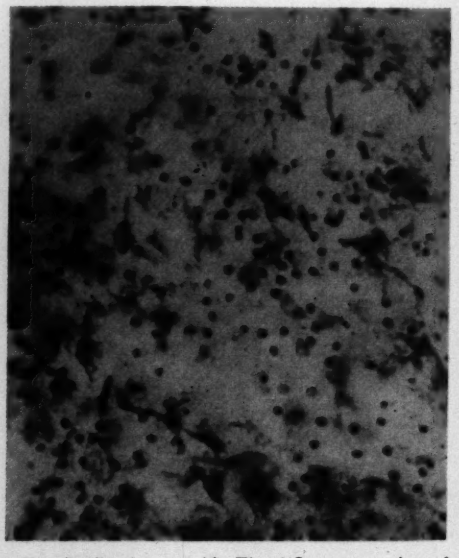

Fig. 7 (Stocker, et al.). Fixed flat preparation of human corneal endothelium after four days' storage in moist chamber at +4°C. In large areas the endothelium is absent. The remaining cells are of variable size and stain faintly (×158). From Stocker.[38]

hydrated and stored at room temperature in his laboratory.[7] The four rabbit corneas received were sealed in glass tubes, two in vacuum. They were clear at this stage. However, upon hydration (according to direction) they became cloudy and edematous as previously reported by King himself.[7] The tissues were separated and tissue cultured as described above. The results were completely negative in all cases, that is, no growth was observed in any culture.

The third method employed was that of glycerol treatment followed by freezing. In addition to glycerol, ethylene glycol was tested. The diluents used were Hanks' balanced salt solution without sodium bicarbonate (RBSS) and oxypolygelatin. Oxypolygelatin was employed because it had been used successfully in preserving skin in a viable condition for three years.[19]

Since the corneas were to be treated for one hour before freezing, the initial experiment was the exposing of corneas to various concentrations of glycerol or ethylene glycol. One series was done with RBSS as diluent, and a second series had oxypolygelatin as the diluent. Concentrations of glycerol or ethylene glycol were 0, 1, 5, 10, 15, 20, 25, 30, 50, 75, 90, and 100 percent. The results may be summarized as follows: (a) all concentrations of ethylene glycol were toxic for all three tissues, that is no positive tissue cultures were obtained; (b) concentrations of glycerol greater than 50 percent were toxic for all three tissues; and (c) RBSS and oxypolygelatin appeared equally satisfactory as diluent.

These preliminary observations were used as the starting point for short-term freezing experiments (one hour to 48 hours). The corneas were soaked for one hour in the preservative at room temperature, and placed at −45C°C., −79°C., or −196°C. No controlled rate or step freezing was done. After one hour at −196°C. or one or two days at −45°C. or −79°C., the tube was removed, placed in a 37°C. water bath to thaw, and then tissue cultured. The results are summarized in Table 1 and are as follows: (a) the epithelial layer is least affected while the endothelium is the most affected; (b) growth of all three tissues was obtained over a wider

TABLE 1

TISSUE CULTURE RESULTS OF RABBIT CORNEAS FROZEN AT VARIOUS TEMPERATURES AND IN DIFFERENT CONCENTRATIONS OF GLYCEROL

Diluent[1]	Glycerol Concentrate (percent)	Storage Temperature[2]								
		−45°C.			−79°C.			−196°C.		
		Ep[3]	S	En	Ep	S	En	Ep	S	En
OPG	1	+[4]	0	0	+	0	0	0	0	0
	5	+	0	0	+	0	0	+	0	0
	10	+	±	0	+	+	+	+	0	0
	20	+	+	+	+	+	+	+	±	0
	30	+	0	0	0	0	0	+	0	0
	50	0	0	0	0	0	0	+	0	0
RBSS	1	+	0	0	+	0	0	0	0	0
	5	+	+	0	+	+	0	+	0	0
	10	+	+	0	+	+	0	+	0	0
	15	+	+	0	+	±	0	+	0	0
	20	+	±	±	±	+	+	+	+	±
	30	+	+	+	+	+	0	+	+	0
	50	+	0	0	0	0	0	+	0	0

[1] OPG = oxypolygelatin; RBSS = Hanks' balanced salt solution without sodium bicarbonate.
[2] Storage interval was one hour for −196°C.; 24–48 hours for −45 °. and −79°C.
[3] Ep = epithelial; S = stromal; En = endothelial cultures.
[4] + = half or more of the cultures were positive; ± = less than half of the cultures were positive; 0 = no migration or proliferation was observed. The number of cultures for each result ranged from two to 10.

TABLE 2

COMPARISON OF TISSUE CULTURE RESULTS WITH RABBIT CORNEAS PRESERVED AT −45°C. AND −79°C.[1]

Length of Storage	−45°C.						−79°C.		
	RBSS			OPG			RBSS		
	Ep[2]	S	En	Ep	S	En	Ep	S	En
2 da.	+[3]	+	+	+	+	+	+	+	+
1 wk.	+	+	+	+	0	+	+	+	0
2 wk.	+	±	±	+	±	0	+	0	0
4 wk.	+	+	+	+	0	0	−	−	−
6 wk.	+	+	0	+	+	0	+	0	0
8 wk.	+	+	0	+	+	0	0	0	0
9 wk.	+	+	0	−	−	−	+	0	0
12 wk.	+	+	+	+	+	0	−	−	−
16 wk.	+	+	±	−	−	−	0	0	0
19 wk.	+	+	±	−	−	−	−	−	−

[1] Preservative fluids were composed of glycerol (20 percent) with either Hanks' balanced salt solution without sodium bicarbonate (RBSS) or oxypolygelatin (OPG) as diluent.

[2] Ep = epithelial; S = stromal; En = endothelial cultures.

[3] + = half or more of the cultures were positive; ± = less than half of the cultures were positive; 0 = no migration or proliferation was observed; − = no cultures were set up. The number of cultures for each result ranged from two to 10.

range of glycerol concentration when RBSS was employed as diluent; (c) at −45°C. positive tissue cultures were obtained over a wider range of glycerol concentration than at either of the other two temperatures; and (d) the optimal conditions from these results appear to include RBSS as diluent and a storage temperature of −45°C.

On the basis of these results long-term storage experiments were set up at −45°C. and −79°C. utilizing both diluents and a glycerol concentration of 20 percent. The results to date are summarized in Table 2 and are briefly as follows: (a) there is no difference in results for a two-day interval with respect to diluent or temperatures, that is, all three tissues survived and grew under all conditions; (b) for longer intervals, the −45°C. temperature has proven superior to −79°C. for protecting the stromal and endothelial layers; (c) at −45°C. the RBSS diluent has been best for protecting the endothelial cells as well as the other two tissues as compared with the oxypolygelatin diluent; (d) the initial observations on the "hardiness" or vulnerability of the three tissues are demonstrated again, that is, the epithelial cells survive and grow over a wide temperature range and long storage times; the endothelium survives over a much narrower range and time; and, (e) in contrast to the observations of Draheim, et al., under the optimal preservation conditions, no changes in the physical appearance of the corneas after prolonged storage were noted. From these results the conclusion is that the optimal conditions are a preservative medium composed of glycerol 20 percent with RBSS as diluent, and −45°C. as storage temperature.

Figure 8 shows growth of epithelium after 19 weeks' storage at −45°C.; Figure 9 growth of stroma under the same conditions. Figure 10 shows the endothelium of rabbit's cornea after storage at −79°C. for two weeks and left in tissue culture for three weeks. The endothelial layer is fairly intact, but the cells have shrunk, and no sign of migration or growth is detectable. In contrast, definite growth of endothelium is seen in Figure 11 after storage of 19 weeks at −45°C.

The pH of glycerol −20-percent RBSS −80-percent was 5.8. Short-term duplicate experiments were performed using buffered Hanks' balanced salt solution as diluent for

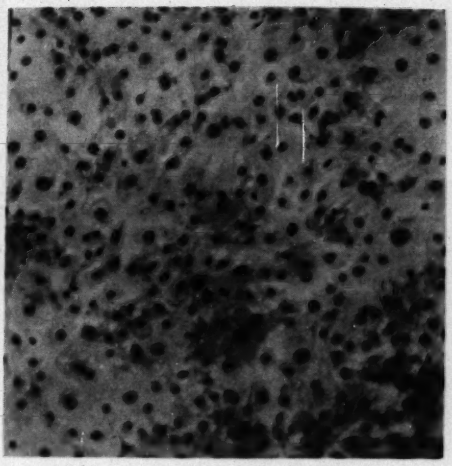

Fig. 8 (Stocker, et al.). Epithelium of rabbit's cornea after storage at −45°C. for 19 weeks. Abundant growth (×140).

one cornea and RBSS for the mate. No difference in results was noted over a 48-hour freezing period. These results obtained over a long storage time using unbuffered balanced salt solution are in contrast to those reported by Leigh and Ridge.[13] They reported that at a pH of 8.8 the endothelium was completely protected from the damaging effects of freezing and thawing by 10-percent glycerol in Krebs phosphate buffer but not at a pH of 5.8. Their results were based on oxygen uptake. However, when grafting operations were performed, out of six grafts, five were opaque and one was "fairly cloudy."

Discussion

The results of our experiments indicate that the endothelium is definitely more vulnerable and reduced in vitality by freezing than the epithelium or stroma. In the light of these results we shall now return to the problem of successful lamellar and unsuccessful penetrating grafts.

Since King has reported beautiful results with lamellar grafts using dehydrated material, it has to be assumed that, for this type of grafting, it is not necessary for the donor tissue to be viable. Proliferation of the recipient cornea probably does readily replace the graft. After all, even after a simple keratectomy, without graft, a fairly normal cornea may be regenerated.

The generally unsatisfactory results obtained by the use of frozen corneas in full-thickness grafts have been mentioned. In the case of one excellent result reported by Iliff,[20] the cornea had been frozen only for one and one half hours at −79°C. It would

Fig. 9 (Stocker, et al.). Stroma of rabbit's cornea after storage at −45°C. for 19 weeks. Abundant growth (×140).

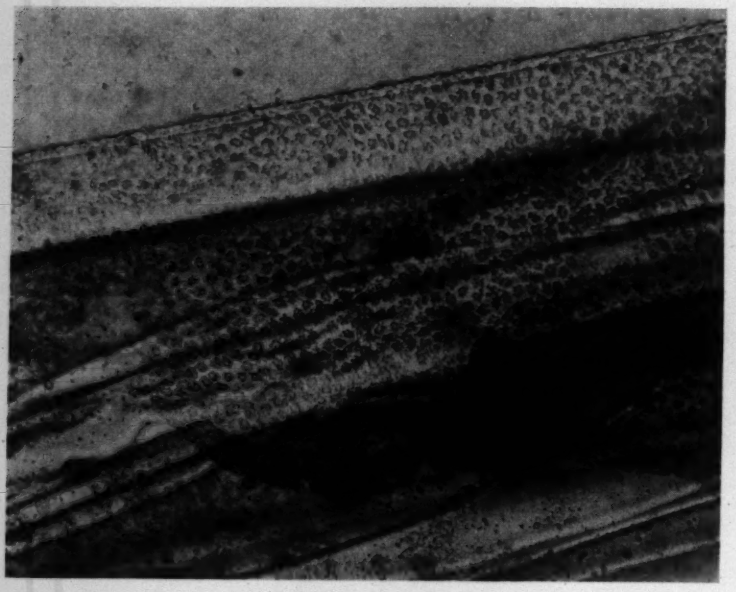

Fig. 10 (Stocker, et al.). Endothelium of rabbit's cornea after storage at —79°C. for two weeks and left in tissue culture for three weeks. The endothelial layer is fairly intact, but the cells have shrunk and no signs of migration or growth is detectable (×265).

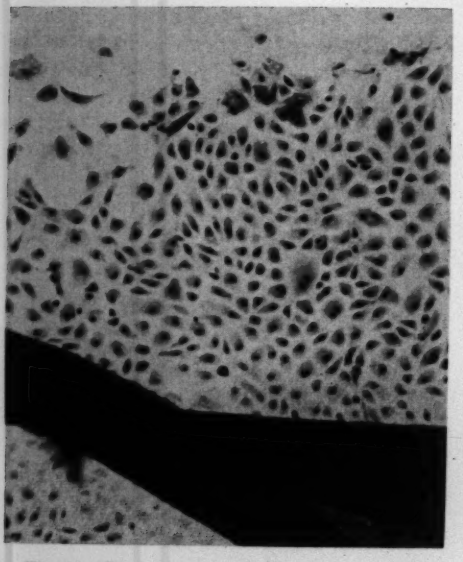

Fig. 11 (Stocker, et al.). Endothelium of rabbit's cornea after storage at —45°C. for 19 weeks. Definite growth. Practically indistinguishable from growth of fresh endothelium (fig. 3). (×145).

appear to be consistent with our experiments that the endothelium would remain viable after having been kept frozen at this temperature for only a short while.

A case reported recently by Rycroft[21] in which a cornea was used which had been frozen and stored at —79°C. for four weeks had an interesting course. The graft at first became more and more opaque until after seven weeks it was completely cloudy. After 17 months it began to clear again and after two years it was completely clear. It may be assumed that in this case the endothelium was severely damaged by the freezing process. Consequently the aqueous humor was able to penetrate into the corneal stroma which led to a cloudiness of the graft. As the endothelium was replaced by the host, clearing of the cornea occurred. While this was a fortunate happening, one would hardly consider such a postoperative course as normal or desirable. Putting aside the question whether the endothelium of a graft eventually

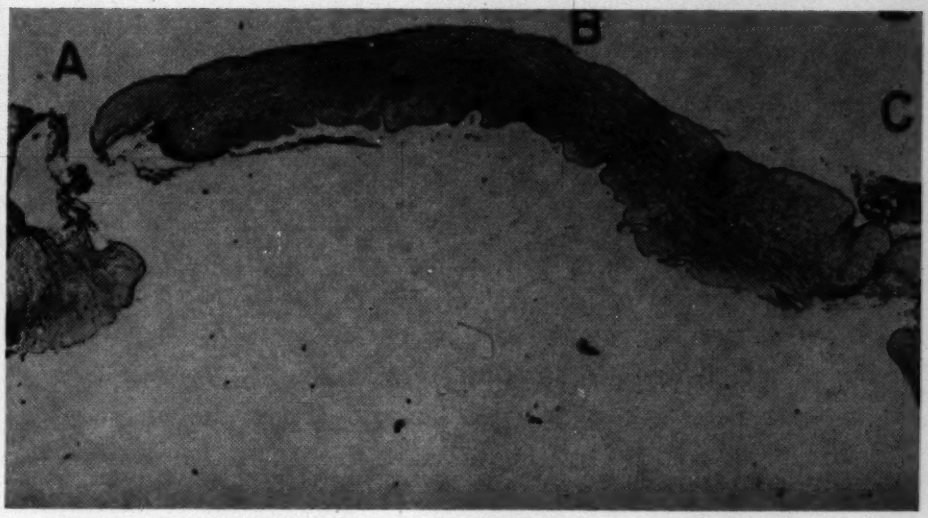

Fig. 12 (Stocker, et al.). Rabbit's cornea four days after a perforating graft had been performed. The endothelium had been scraped from part B-C which is much thicker (edema) than part A-B where the endothelium was left intact. From Stocker.[18]

will be replaced by the recipient, an intact endothelial layer seems to protect the graft from becoming edematous in the early stages.

Figure 12 demonstrates how, even in the same graft, the part from which the endothelium had been scraped off is considerably thicker, from absorbing fluid, than the part which was covered by normal endothelium. Early edema causing cloudiness of the graft, clinically, is an undesirable symptom. While in some cases eventually a clear graft may result, the prognosis is not as good as if the graft stays clear from the beginning. Thus an intact viable endothelium appears to be of paramount importance for obtaining clear penetrating grafts.

It should be remembered that all the aforementioned reports deal with donor corneas which had been frozen at −79°C. or −196°C. Since our experiments clearly indicate that a storage temperature of −45°C. is much less harmful to the delicate endothelium more favorable results might be obtained by using this method of preservation.

Rycroft[21] stated that more recent corneal graft cases with modification of the deep freeze technique had given very encouraging results and that in his opinion this method will become the bank method of preservation for the future. However, he did not specify what the modifications of the technique were.

In planning our experiments we were guided by the desire to devise a method as simple and practical as possible, that is, no step-wise freezing or controlled rate of freezing was done. The method should be easily performed even in small hospitals.

When trying to determine the best method of preserving corneal tissue, the ultimate decision, of course, will have to be based on the clinical experience. The information obtained by in vitro techniques should be of great value in deciding whether or not one is justified to use preserved tissue clinically.

Summary and Conclusions

The effect of various methods of preservation on the viability of the three types of tissue of the rabbit cornea was examined by setting up between 1,000 to 1,050 tissue cul-

tures using a method developed in this laboratory for growing the three corneal tissues individually.

In general the epithelium was found to be the least affected by the process of preservation. The endothelium suffered the most.

Positive cultures from all three layers were obtained after preservation of corneas in mineral oil at +4°C. for periods up to five weeks but no longer.

No growth was obtained from corneas dehydrated by the method of King.

Of the freezing techniques, storage in 20-percent glycerol and 80-percent Hanks' balanced salt solution without sodium bicarbonate at −45°C. gave the most satisfactory results. Positive cultures from all three layers were obtained after as long as 19 weeks of storage.

Grafting experiments are now being performed with preserved and stored corneas.

1110 West Main Street.

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THE SURGICAL SEPARATION OF THE CORNEOSCLERAL TRABECULUM FROM ITS BED*

I. Anterior trabeculodialysis

Angelos Dellaporta, M.D.
San Francisco, California

Ever since Knies[14] and Weber[18] discovered, in 1876, the frequency of obstruction of the angle of the anterior chamber in glaucoma, the classical concept, particularly as propounded by Priestley-Smith, was that the obstruction of the drainage angle constituted the main cause of increased intraocular pressure.

In 1892, de Vincentiis[17] theorized that glaucoma was caused by the failure of the aqueous to reach Schlemm's canal because of alterations in the corneoscleral trabeculum and conceived the idea of cutting open the latter by introducing a knife into the anterior chamber thus opening Schlemm's canal. The attempt was unsuccessful because he did not see where he was cutting with the knife.

In the following years the fistulizing operations were introduced and proved to be successful and so easy to perform that they superseded all the previous antiglaucomatous procedures for open-angle glaucoma, and even Graefe's iridectomy for acute glaucoma.

In the following decades intensive work on the glaucoma problem and improved techniques in gonioscopy showed that in early open-angle glaucoma the angle of the anterior chamber does not show within it pathologic changes which would account for obstruction of the drainage of the aqueous. It was rationally concluded that the obstruction must lie in the trabecular meshwork or in the adjacent Schlemm's canal or its outflow channels.

Otto Barkan revived de Vincentiis' procedure by developing an ingenious technique called goniotomy or trabeculotomy† in which he cut open the corneoscleral trabeculum under direct visualization with a contact lens. In 1936[3] he reported on 17 eyes with open-angle glaucoma operated by trabeculotomy, and at about the same time approximately 15 additional eyes were treated similarly.[8] The final operative results were disappointing because in only one third of the operated eyes was the intraocular pressure normalized.[8] Gonioscopy of the operated eyes showed a slitlike opening of the inner aspect of the corneoscleral trabeculum extending to about one fourth to one fifth of the angle circumference proving that the innermost trabeculae were cut open. In those cases in which Schlemm's canal could be filled with blood by the jugularis pressure method it was found that in the region of the operative slit the red color of the blood column was more intense than elsewhere, but gonioscopically no blood entered the anterior chamber. This proved that at the time of gonioscopy Schlemm's canal did not communicate freely with the anterior chamber. Either the knife failed to cut open the entire thickness of the corneoscleral trabeculum during the operation or, if it did, Schlemm's canal closed again by reapposition of the slit trabeculae.

* From the Division of Ophthalmology, Department of Surgery, Stanford University School of Medicine. This investigation was supported by Traineeship Grant BT-328, United States Public Health Service. Presented in part before the Association for Research in Ophthalmology, Western Section, San Francisco, November 17-18, 1958.

† In a later paper, Otto Barkan[4] writes: "Goniotomy in infants and in adults is two distinct operations which differ in rationale, technique and effectiveness. In infants, the operation which has been developed to a relatively satisfactory conclusion, consists of removing occluding fetal meshwork from the angle. In adults, in whom it has not yet shown an adequate degree of consistent efficacy to recommend its employment except in the occasional case, its objective is to incise the angle wall, that is, the trabeculum proper. For this reason, it is suggested that the term goniotomy be applied only to the operation performed on infants, and goniotrabeculotomy or trabeculotomy to the procedure carried out in adults."

The poor results in normalizing the intraocular pressure and the difficult technique of trabeculotomy in adults compared unfavorably with the conventional fistulizing operations and, therefore, Barkan abandoned this procedure for open-angle glaucoma in adults.[5,7] However, goniotomy proved to be successful in infantile glaucoma.[5,6]

The work of Kronfeld,[15] Ascher,[2] Goldmann,[9,10] and especially the introduction of electronic tonography by Grant,[11,12] spurred intensive work on the aqueous outflow and the site of the resistance to the aqueous outflow in normal and in glaucomatous eyes. Grant[13] in his latest work measured the facility of aqueous outflow by perfusion before and after trabeculotomy or trabeculectomy under direct view with a dissecting microscope, and found in a series of 16 presumably normal eye-bank eyes that the trabecular meshwork is responsible for 75 percent of the resistance to the aqueous outflow. These studies indicate that the corneoscleral trabeculum is also the probable site of the increased resistance to the aqueous outflow in open-angle glaucoma. Removal of the corneoscleral trabeculum from its bed would logically increase the facility of aqueous outflow in normal and probably in glaucomatous eyes.

In exploratory experiments on monkeys undertaken by Dr. Flocks and me it was attempted to improve Barkan's technique of trabeculotomy by using various instruments with the active point bent so that the corneoscleral trabeculum could be reached more easily. These investigations continue.

The normal topographic relation (fig. 1) of the corneoscleral trabeculum to the scleral spur and the ciliary body made me speculate on what happens to the trabecular meshwork if the ciliary body is separated from the sclera by a classical cyclodialysis of Heine. In three pathologic specimens from enucleated eyes which had undergone cyclodialysis and which showed histologically an open subchoroidal cleft, it was found that the corneoscleral trabeculum had separated from the ciliary body and was visible on its normal bed covering Schlemm's canal.

It was theorized that this finding is to be

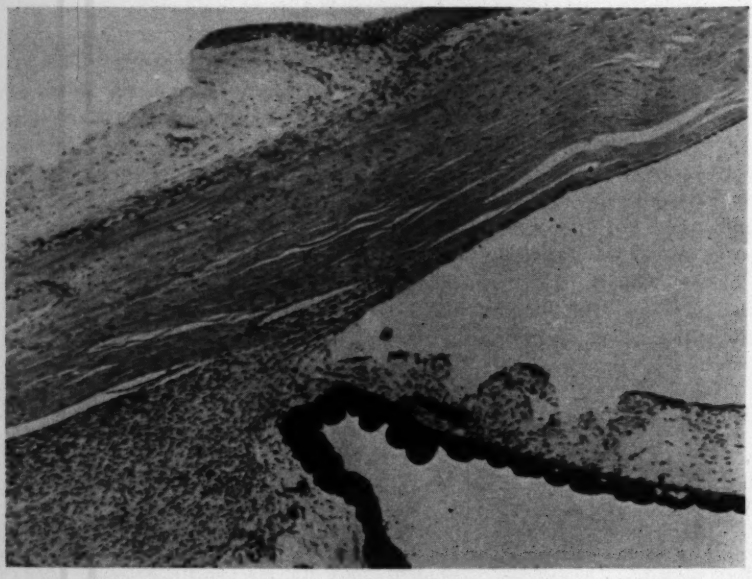

Fig. 1 (Dellaporta). Normal angle of a 38-year-old man. Eye enucleated because of malignant melanoma.

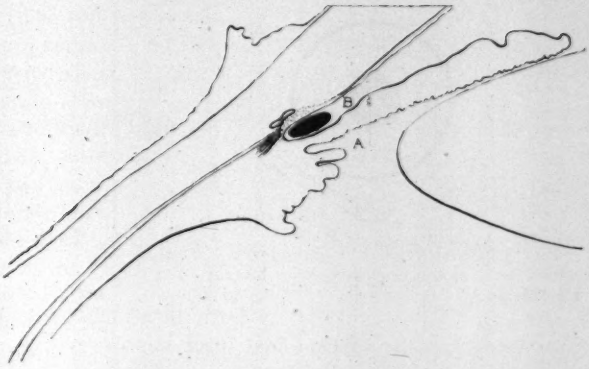

Fig. 2 (Dellaporta). Drawing showing the position of the spatula relative to the structures of the angle just before the separation of the ciliary body in Heine's cyclodialysis.

expected since in Heine's cyclodialysis the spatula, after appearing in the anterior chamber, is rotated in a sweeping clock or anticlockwise movement in order to effect a blunt separation of the ciliary body from the sclera. During this movement the spatula glides snugly on the posterior surface of the cornea, passes smoothly under the corneoscleral trabeculum, and engages in the angle of the anterior chamber (fig. 2) being then in contact anteriorly with the corneoscleral trabeculum and the scleral spur, laterally with the uveal meshwork, and posteriorly with the root of the iris. Continuing its sweep posteriorlaterally, the spatula severs the corneoscleral trabeculum from the uveal meshwork just behind the scleral spur and enters the subchoroidal space. In this way the corneoscleral trabeculum remains attached to its bed covering Schlemm's canal.

Asayama[1] and Salzmann[16] in their careful anatomic studies found that if one detaches (tears) the ciliary body from its insertion to the sclera from behind, the corneoscleral trabeculum remains clinging to the anterior end of the ciliary body. The main reason for these anatomic results was, in my opinion, the fact that the ciliary body was separated from its insertion from behind, and the most promising method to achieve the same result in undissected normal eyes seemed to be the following: Instead of tearing the uvea from the sclera one could introduce a blunt spatula into the subchoroidal space near the limbus and approach the circular corneoscleral trabeculum tangentially in an extremely slow sweeping movement of the spatula in the hope that with the separation of the ciliary body from its insertion the corresponding section of the corneoscleral trabeculum would be detached from its bed.

Technique

The experiments were carried out on eyebank eyes which were kept under refrigeration (5°C.) from the time of the enucleation two to three hours after death until they were used three to 72 hours later. The whole eye was placed in one of the wooden devices for holding enucleated eyes which are used in our department for training in eye surgery. With a small Bard-Parker knife the meridians at the 3-, 9-, 6-, and 12-o'clock positions at the limbus were marked so that the circumference of the angle was divided into four quadrants. After the surgical treatment the whole eye was fixed in 10-percent formalin, sectioned into the four premarked quadrants, embedded in paraffin, and studied histologically in serial meridional sections stained with Masson's trichrome stain or with hematoxylin-eosin.

Preliminary surgical procedures

Method A. A 2.5-mm. long scleral incision was made 3.0 mm. posterior and parallel to the limbus. Elschnig's flat cyclodialysis spatula with rounded tip and rounded edges was

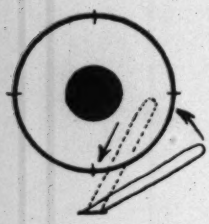

Fig. 3 (Dellaporta). The preliminary Method A which is a modified cyclodialysis inversa of von Blaskovics.

introduced into the subchoroidal space tangentially to and 3.0 mm. posterior to the limbus and pushed carefully forward until it covered approximately one quadrant of the circumference of the angle. The spatula was then rotated with a very slow sweeping movement toward the angle of the anterior chamber until it was visible through the cornea, and then withdrawn (fig. 3).

Method B. Elschnig's spatula was introduced into the subchoroidal space through a 2.5-mm. long scleral incision, placed 3.0 mm. from and parallel to the limbus, and a classical cyclodialysis of Heine was performed covering one quadrant of the eye (fig. 4). The ciliary body was separated for a distance of only 3.0 to 4.0 mm. from the limbus since the objective was the separation of its insertion only. The eyes treated by this method were designated as controls.

Results. Sixty-nine operations were performed using either Method A or B, but the results were disappointing because in the great majority of the specimens the corneoscleral trabeculum was found separated from the ciliary body and adherent to its bed covering Schlemm's canal. However, in a few specimens the corneoscleral trabeculum was found in its entire thickness detached from its bed and clinging to the separated ciliary body. This proved that the objective of the operation was feasible.

Method C. Having in mind the studies of Asayama and Salzmann and theorizing that the separation of the ciliary body and the corneoscleral trabeculum should be achieved by tearing apart the uvea from the corneoscleral junction rather than separating it by a flat spatula, a metal rod with smooth surface, one mm. in diameter, was bent in the shape of Elschnig's spatula. With this instrument Method A and, in a few cases, Method B were performed in 29 operations. The results were negative in all cases.

In further experiments in which Method A, B, or C was used, the possible influence of: (1) the presence or absence of the anterior chamber, (2) the intraocular pressure, (3) the sex and age of the donor, (4) the freshness of the material (eyes), and (5) the temperature of the treated eyes, at the time of the operation as well as technical variations of the three methods were evaluated but no relation was found between these factors and the results obtained.

The final statistical evaluation of the results of 98 operations showed:

1. That the few positive results were produced mostly by Method B, that is the modified cyclodialysis of Heine. These eyes were actually intended as controls.

2. That the positive cases were obtained during the first operations where technical difficulties during the execution of the operation had to be overcome.

A careful scrutiny and re-enactment of the conditions prevailing during these first operations indicated that the determining factor for a successful separation of the corneoscleral trabeculum was possibly the angle at which the flat spatula approached and treated the angle structures. In further experiments this proved to be correct.

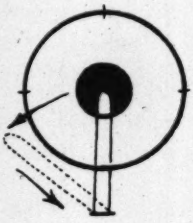

Fig. 4 (Dellaporta). The preliminary Method B which is a modified cyclodialysis of Heine.

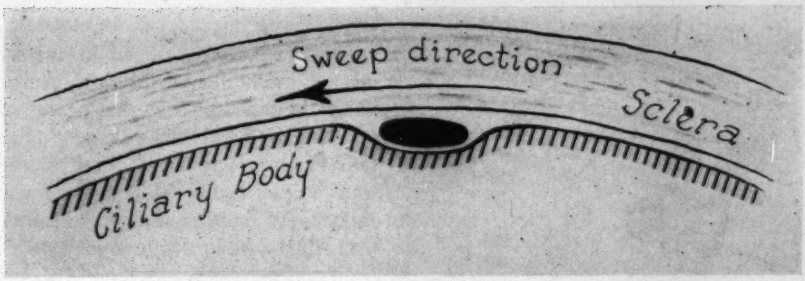

Fig. 5 (Dellaporta). Shows that in Heine's or von Blaskovics' cyclodialysis the blade of the spatula is parallel to the corneosclera during the sweeping movement.

Anterior trabeculodialysis

Preliminary remarks

The standard cyclodialysis spatula of Elschnig consists of a handle, a shaft, and the spatula proper or blade; the term "blade" will be used here. During a classical cyclodialysis performed on a patient in prone position the flat surface of the blade is parallel to the sclera and in a horizontal plane (fig. 5); in order to maintain this correct position during the sweep the handle of the instrument is held approximately at the vertical. Let it be assumed that this position of the instrument, the vertical handle, and the horizontal blade, is the "standard."

For the final technique in the present operation Elschnig's spatula was used as manufactured by Storz (Catalogue #E-488) after modifying it as described below:

The whole blade was bent by rotating it along its long axis so that the plane through its flat surface formed a 135-degree angle with the handle and shaft of the instrument. If one performed a classical cyclodialysis with such a modified instrument with the handle in the "standard" vertical position the blade would not be parallel to the sclera but would form a 45-degree angle with its inner surface (fig. 6). For further clarification: Assuming that the surgeon is standing, and holds the handle of the modified instrument parallel to his erect body in the "standard" position with the blade pointed away from him, the left edge of the flat blade tilts to the left and upward, and the right edge slopes to the right and downward. This instrument is designed for the right-handed surgeon.

The enucleated eye was placed in the wooden holder as previously described in the preliminary technique, the cornea upward, and a 22-gauge injection needle was intro-

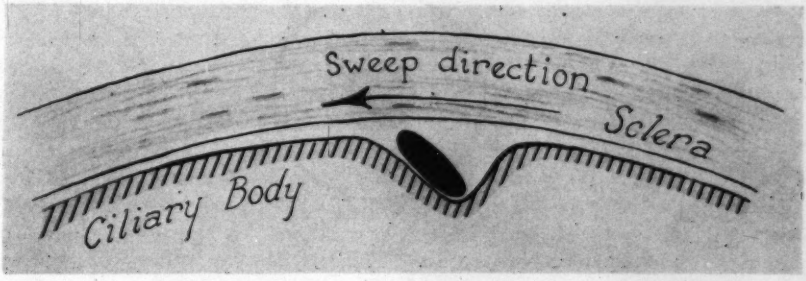

Fig. 6 (Dellaporta). Shows that when the handle of the angulated spatula is held in the standard erect position as in cyclodialysis the flat surface of the blade of the spatula forms a 45-degre angle with the inner surface of the corneosclera and only its left (active) edge is in contact with the inner surface of the corneosclera during the sweeping movement.

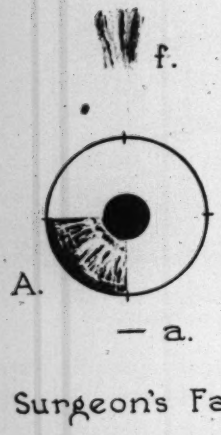

Fig. 7 (Dellaporta). The proper position of the eye and of the surgeon during the final technique. (A) Quadrant of the eye which is to be treated; note its position in relation to the face of the surgeon. (a) Scleral incision. (f) Fixation of the eyeball.

duced into the vitreous cavity by perforating the sclera near the equator. The needle was connected by a plastic tube to a transfusion bottle hanging from a stand. By changing the height of the bottle the intraocular pressure could be varied at will. In most operations the tension was held between 17 and 24 mm. Hg though in some instances it was as low as 4.0 mm. Hg as measured by the Schiøtz tonometer (1955 scale).

Operation

The eye was positioned in front of the surgeon so that the quadrant of the eye which was to be operated was that nearest the left side and left hand of the surgeon (fig. 7-A). This position was the standard in every operation described below and was consistently obtained by rotating each eye as necessary.

1. A 2.0-mm. long scleral incision, 3.0 mm. from and parallel to the limbus, was made at the 6-o'clock meridian (fig. 7-a).

2. The handle of the angulated spatula being tilted to the surgeon's left at a 45-degree angle to the vertical, the blade was introduced through the scleral incision into the subchoroidal space with its flat surface parallel to the inner surface of the sclera. With the tip directed not toward the center of the cornea but slightly to the left, the spatula was pushed slowly forward until a few millimeters of the blade were seen through the cornea (fig. 8-A). During this movement the instrument was being pulled slightly away from the eye so that injury to the ciliary body was avoided.

3. The handle of the instrument was then turned erect to a position given by a straight line passing through the handle and shaft of the instrument and the center of the eye. At this erect position the flat surface of the blade forms a 45-degree angle with the inner surface of the cornea, its long axis forms a nar-

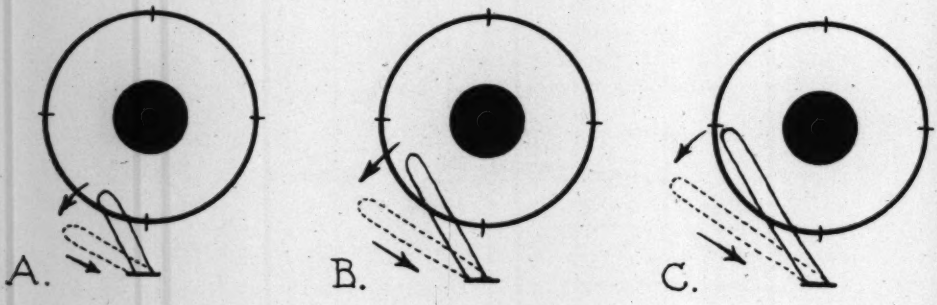

Fig. 8 (Dellaporta). Shows the successive steps of the final technique. Position of the blade of the angulated spatula before the first sweep (A), before the second sweep (B), and before the last sweep (C). Dotted line indicates the position of the blade of the spatula before withdrawal.

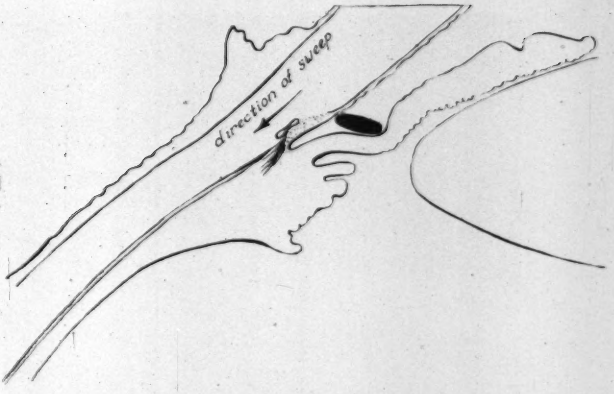

Fig. 9 (Dellaporta). The position of the blade of the angulated spatula before reaching the corneoscleral trabeculum.

row angle with the corneoscleral trabeculum, and only its left upper edge is in contact with the inner surface of the corneosclera (figs. 8-A and 9). The handle, being pulled gently but firmly away from the eye, was slowly rotated to the left so that the blade performed a slow sweep toward the angle and passed the corneoscleral junction against the resistance of a slightly felt furrow. During this manipulation the left upper edge of the blade gently scraped the inner surface of the corneoscleral junction. When the blade appeared to be about 3.0 to 4.0 mm. from the limbus under the sclera it was slowly withdrawn. In this way approximately one third of the quadrant had been treated.

4. Before the tip was withdrawn from the scleral incision the blade was re-introduced into the anterior chamber and the second third of the quadrant was treated with the same maneuver as described above under paragraph 3 (fig. 8-B).

5. The third section of the quadrant was treated in a similar way as the second and the spatula was finally withdrawn (fig. 8-C).

During the re-introduction of the blade into the anterior chamber for the second and third sweeping movements the handle was held erect in the position in which the first sweep was performed.

During the entire operation the eye was fixed with a forceps grasping the insertion of the rectus muscle lying opposite the scleral incision (fig. 7-f).

Histologic results

Fifty-eight cases were operated with the above described method and were studied in serial meridional sections stained with Masson's trichrome stain or hematoxylin-eosin.

In three of the treated cases (five percent) the innermost portion of the corneoscleral trabeculum was found detached and clinging to the separated ciliary body; the outermost portion, comprising one third to two thirds of the total number of the trabeculae, was found attached to its normal position covering Schlemm's canal (fig. 10). These cases were considered negative since the operation failed to open Schlemm's canal anatomically.

The remaining 55 cases (95 percent) showed the following (figs. 11 to 15):

Descemet's membrane and the corresponding endothelium showed a limited detachment in the periphery of the cornea rarely exceeding two mm. in width. The corneoscleral trabeculum had detached from its bed and was found clinging to the separated ciliary body. As a consequence Schlemm's canal opened, its lumen disappeared, and the remaining sulcus was communicating freely with the anterior chamber. In approximately one fourth of the cases (operations) the endothelium lining the outer wall of Schlemm's

Fig. 10 (Dellaporta). Anatomically unsuccessful operation. Limited cyclodialysis. The bulk of the trabecular fibers remained covering Schlemm's canal. This anatomic result is regularly obtained after the cyclodialysis of Heine or that of von Blaskovics.

Fig. 11 (Dellaporta). Successful operation. Separation of the ciliary body from the sclera. The corneo-scleral trabeculum has been detached from its natural bed and is clinging to the anterior end of the ciliary body. Schlemm's canal has been changed into a shallow furrow which forms part of the anterior chamber.

Fig. 12A (Dellaporta). Typical result after successful operation. Detached corneoscleral trabeculum adhering to the separated ciliary body. Schlemm's canal is open. A piece of Descemet's membrane nearby.

Fig. 12B (Dellaporta). Higher magnification of Schlemm's canal from Figure 12A. On the anterior (left) end of the latter remnants of trabeculae; on its posterior (right) aspect the scleral fibers are split; some cells of the endothelium of Schlemm's canal are seen below its outer wall.

Fig. 13 (Dellaporta). Successful operation. Part of the scleral spur has been detached together with the corneoscleral trabeculum. The latter is folded back due to the backward sweep of the blade of the spatula during the operation.

canal was absent to a considerable extent, indicating probable damage through the operation.

The scleral spur had in many cases separated from the sclera and remained clinging to the base of the detached corneoscleral trabeculum. In several cases it was found in its normal place, and in the remaining instances it was histologically not detectable. In approximately one fourth of the cases the innermost scleral fibers near the scleral spur at the posterior aspect of Schlemm's canal were split from the main body of the sclera probably owing to undue pressure of the spatula against the corneoscleral capsule.

The ciliary body showed a limited separation from the sclera in its anterior portion not exceeding four to five mm. from the scleral spur.

Comment

The angle at which the blade of the spatula approaches the corneoscleral trabeculum and separates it from its bed is the essential factor for a successful operation. It is therefore necessary to place the quadrant of the eye which is to be treated in the most convenient position for the right-handed surgeon who uses the above-described angulated instrument. The quadrant has to face the left side of the surgeon. Naturally, one could angulate the blade of the spatula differently in such a way that when the instrument is held in the "standard" position the left edge would be sloping to the left and downward, the right edge upward and to the right. In this case the sweep would have to be performed to the right, but in my experience the rotation of the instrument to the right is awkward for the right-handed person. In addition, at the proper position it is easy to tilt the handle of the instrument sufficiently to the left so that the blade is introduced into the subchoroidal space parallel to the sclera and thus avoid injury to the ciliary body.

The blade of the spatula is directed toward the angle and slightly to the left of the center of the cornea in order to avoid as much as possible damage to the endothelium and Descemet's membrane.

Fig. 14A (Dellaporta). Open Schlemm's canal. The corneoscleral trabeculum is not visible on the separated ciliary body. Piece of Descemet's membrane visible.

Before the sweeping movement is executed it is advisable to pause for a few seconds to make sure that the handle of the instrument is in the correct upright position, otherwise the blade will be at the wrong angle and its left edge will not reach and detach the corneoscleral trabeculum.

During the sweep the instrument has to be pulled gently but firmly and steadily away from the eye, otherwise the left edge of the

Fig. 14B (Dellaporta). High magnification of Schlemm's canal from Figure 14A. Endothelium of Schlemm's canala intact.

Fig. 15A (Dellaporta). Open Schlemm's canal. The detached corneoscleral trabeculum is adherent to the anterior end of the ciliary body. Split scleral fibers on the posterior aspect of Schlemm's canal.

blade will not reach the corneoscleral trabeculum. When the blade actually detaches the corneoscleral trabeculum this is felt with the fingers holding the instrument as if passing over a narrow furrow (Schlemm's canal). This resistance is greater when performing the second and the third sweep.

During the sweeping movements the corresponding section of the iris and pupil are dislocated peripherally toward the direction

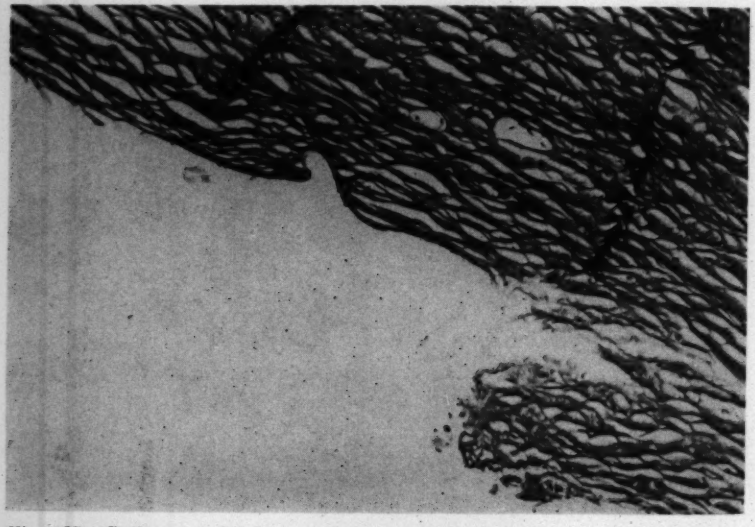

Fig. 15B (Dellaporta). High magnification of Schlemm's canal from Figure 15A.

of the sweep, as often happens in the classical cyclodialysis. They usually slip back spontaneously to their proper position as soon as the blade is seen under the sclera three to four mm. from the limbus. It is not necessary for the handle of the instrument to be tilted to the left in the second and third sweeping movements as it is in the first, because the blade then re-enters the anterior chamber through the existing subchoroidal cleft, thus avoiding danger of injury to the ciliary body.

The operation should be performed in three separate stages so that three equal chances of success are offered.

Summary

A surgical procedure has been developed and is described here by which the corneoscleral trabeculum is detached from its natural bed causing Schlemm's canal to communicate freely with the anterior chamber. The method was developed in normal eye-bank eyes and was successful in 55 (95 percent) out of a total of 58 operations. In analogy to similar terms the name anterior trabeculodialysis is proposed.

490 Post Street (2).

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CYCLODIALYSIS WITH SCLERAL SHRINKAGE FOR OPEN-ANGLE GLAUCOMA*

Bennett Y. Alvis, M.D.
Saint Louis, Missouri

The operative procedure here presented is a modification of a technique devised by Dr. James H. Allen.[1] As described by him the essential features of the operation were a radial scleral incision extending upward from the limbus for one or two mm., then enlarged downward to enter the anterior chamber, with the separation of the ciliary attachment to the scleral spur each way from the incision for a distance equal to one fourth of the limbal circumference. This is carried out under a limbal-based conjunctival flap and differs from the classical cyclodialysis

*From the Department of Ophthalmology, Washington University School of Medicine. Presented at the 94th annual meeting of the American Ophthalmological Society, White Sulphur Springs, West Virginia, May, 1958.

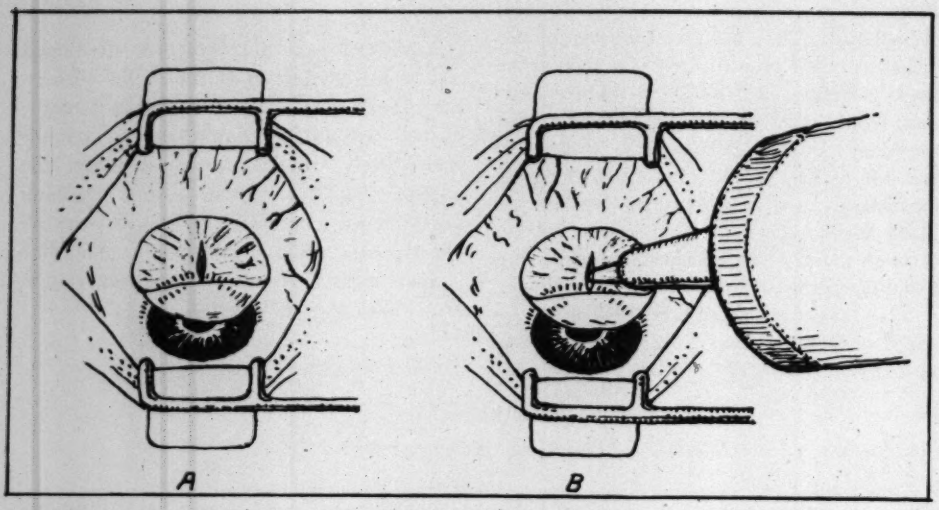

Fig. 1 (Alvis). (A) Conjunctival flap has been turned down to the limbus. The scleral surface has been bleached by use of cautery and a vertical incision has been made through the sclera. (B) The cautery is applied to the cut edge of the scleral incision to stop a bleeding vessel.

procedure in three essential features: (1) the direction of the incision—vertical to the limbus instead of parallel to it; (2) the location of the incision adjacent to the cornea; and (3) the limitation of the ciliary separation from the sclera to a narrow zone including little more than the ciliary attachment to the scleral spur (fig. 1).

The modification here presented is the application of the heated coagulator tip along the line of the incision and to any bleeding point in the cut edge of the scleral wound. This maneuver serves two purposes. It prevents bleeding from the scleral and episcleral vessels into the anterior chamber and it causes a shrinkage of the scleral fibers and produces a gaping of the scleral opening which is very slow in closing. In some of the cases the fistulous tract thus produced has remained functional to date, some as long as seven years.

The fact that heat applied to the margins of a scleral wound causes the scleral tissue to shrink and thus produce a gaping wound was recognized by Scheie[3] who utilized this principle in a fistulizing operation presented at the academy meeting in Chicago in 1957.

The mechanism of the cyclodialysis operation was discussed by Kronfeld[2] before this society in 1954. He noted two factors by which the lower level of intraocular pressure is maintained: (1) a depressing effect on the secretory function of the ciliary body and (2) an increase in the facility of outflow by way of the suprachoroidal cleft. Both of these functions are dependent on the maintenance of a patent supraciliary cleft. It is well known that a large percentage of cyclodialysis operations show a tendency toward closure of the cleft and to lessened efficiency in maintaining a lowered intraocular pressure. Kronfeld concludes with the statement: "All in all, the final result of the cyclodialysis operation is less controllable by the ophthalmologist than is the final result of any other glaucoma operation."

Allen in discussing the paper by Kronfeld states that "as soon as the cleft is closed, the patient gets into trouble" and that "all of these clefts will close sooner or later unless a very large dialysis is made in the beginning."

That the operation presented here owes its effectiveness to external filtration rather than the maintenance of an open cyclodialysis cleft is evidenced by the fact that most of the older operations in this group which maintain a satisfactorily lowered intraocular pressure show gonioscopically a closure of the cleft in the operated area. The angles elsewhere are open but appear to be closed in the area of the dialysis. The conjunctiva shows evidence of escaping aqueous either in a flat boggy area over the scleral wound or in a typical filtration bleb.

In Table 1 is a report of 22 eyes of private patients with chronic glaucoma subjected to cyclodialysis by the following technique:

A radial incision was made three mm. vertical to the limbus under a six-mm. limbal-based flap of conjunctiva and Tenon's capsule. The flap was carried to the limbus. The episcleral vessels were coagulated with the Hildreth cautery along the site of the incision, making a white path of bare sclera which was then incised with a sharp Graefe or pointed Bard-Parker knife, cutting at right angles to the surface (fig. 1-A). The opening in the sclera was extended from the limbal angle just far enough to admit the cyclodialysis spatula which was then passed to right and left freeing the scleral spur but was not swept into the suprachoroidal space over the ciliary body (fig. 2).

If during the incision bleeding occurred, the hot coagulator tip was applied to the bleeding point (fig. 1-B). The tip should be hot enough to bleach the sclera along the course of the incision.

Usually a little blood escaped in freeing the ciliary spur, easily controlled by injecting air into the anterior chamber. The conjunctiva and capsule were closed with a single running suture.

The first eyes operated by this method seven years ago healed with little reaction and maintained normal tension and vision. Soon a flat filtering area became visible and it was evident that the effectiveness of the procedure was due, in part at least, to external filtration. The fistulous opening in the sclera, which in most of these cases has remained permanent so far, is probably due to the shrinkage of the sclera by the heat of the cautery tip applied to coagulate the blood vessels.

Of these 22 eyes 12 have maintained normal tension without miotics; four with treatment; three partly controlled; and two required iridencleisis; one was lost.

One eye has retained original vision seven years; two, four and a half years; one three years; six for one to two years. Others have suffered some deterioration of vision, mostly from lens changes. In several of these the changes in the unoperated eye ran parallel to those of the operated eye.

In Table 2 is presented a summary of the results obtained in 18 eyes of patients from the Glaucoma Clinic of Washington University Medical School. These eyes had radial cyclodialysis with scleral shrinkage by Dr. Charles Barnes to whom I am indebted for the study of the results. Most of these eyes had some other procedure performed on them either before or after the radial cyclodialysis. The tension of eight eyes of this group was not controlled by this procedure even with supplementary treatment. Eight others were

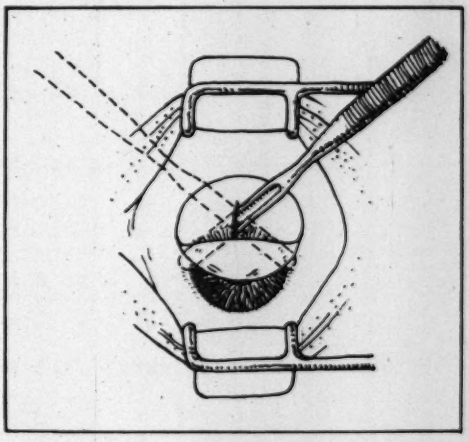

Fig. 2 (Alvis). The spatula breaks the scleral spur to horizontal meridian nasally and temporally.

TABLE 1

TWENTY-TWO EYES (18 PATIENTS) SUBJECTED TO CYCLODIALYSIS FOR CHRONIC GLAUCOMA

Case No.	Sex Age (yr.)	Date	Tension (mm.Hg)		Vision		Gonioscope After Surgery	Tension control		Field	Follow-up
			Before	After	Before	After		C Rx	S Rx		
1 S. K.	M 66	O.S. 6/ 7/49	27	18	6/12	6/12	Open		Yes	Progressive loss to 5°	Nine years downhill with tension always low
2 W. B.	M 64	O.D. 11/30/50	47	24 to 37	6/6	6/6	Closed above	Partly	No	Slight loss	Six years required miotics and finally repeat cyclodialysis
		O.S. 4/12/51	37	21	6/6	6/6	Open	—		Full field	
3 E. W. C.	F 60	O.D. 1/22/51	34	19	6/12	6/25	—	Yes	No	Marked loss before op.	Five-year control; three yr. by me. Reported under control after six yr.
4 A. E.	F 65	O.D. 5/3/51	42	23	2/60	3/15	Closed above	No	No	Contracted before surgery	Three yr. of fair control; finally rose to 60 mm.Hg and reported blind.
5 C. H.	M 50	O.D. 10/21/51	37	10	6/10	6/10	Closed above		Yes	Contract—10° before surgery	Six yr. after operation; tension 24 mm.Hg, vision 6/12.
		O.S. 7/15/52	31	12	6/5	6/5	Closed above	Yes			Five yr. after surgery; vision, tension normal
6 J. N.	M 56	O.D. 11/ 7/52	33	20	6/12	6/10	—	Partly	No	Contracted	Both discs pale and cupped. Cataracts removed one yr. after glaucoma surgery.
		O.S. 12/15/52	43	23	6/15	6/25	—	Partly	No	Contracted	Tension controlled by Diamox. Fields contracted greatly. Left central vision 6/10.
7 T. C. L.	F 78	O.S. 1/20/53	37	22	6/75	6/10	—	—	Yes	Slightly contracted	Left eye five yr. after surgery maintains normal tension without treatment. Vision obscured by cataract. Right controlled with great difficulty by medication.
8 J. M. W.	M 56	O.S. 1/28/53	17	27	6/25	6/30	Closed	No	No		Iridencleisis 3/16/53 both eyes because of acute congestive attack
9 P. F.	M 43	O.S. 6/24/53	31	16	6/5	6/5	Closed above	—	Yes	Arcuate scotoma	Five yr. Tension has been well controlled in spite of episodes of nervous exhaustion. Vision deteriorating both eyes, now 6/10

Case No.	Sex Age (yr.)	Date	Tension (mm.Hg)		Vision		Gonioscope After Surgery	Tension Control		Field	Follow-up
			Before	After	Before	After		C Rx	S Rx		
10 L. H.	M 60	O.S. 4/ 9/54	34	17	6/10	6/7.5	Angle open except above; cleft scarred over; filtering bleb	—	Yes	Full	Four yr. of normalized tension without medication. Tonogram 11/1/56. Tension O.D. 29, facility 0.16; O.S. 10, 0.26
11 J. C. F.	M 56	O.S. 12/28/54	37	20	6/4	6/4	Closed above	Yes	No	Full	Requires 2% pilocarpine every 8 hr. which now controls tension in left eye 2 yr. after operation
12 R. P.	M 67	O.S. 4/21/55	39	13	6/5 Three yr. later vision 6/12 each eye	6/5	Closed above, open elsewhere, R. angle open	—	Yes	Seidel left eye before surgery	Two yr. Tonogram 10/56; tension O.D. 17, facility 0.17. Tension, O.S., 13; facility 0.33. After water drinking: tension, O.D., 21, O.S., 16; facility, 0.18, 0.32.
13 D. H.	M 65	O.S. 12/16/55	42	49	6/10	6/6	Closed	At times 2 mo. after op. Tension 49 mm.Hg			Three yr. later tension partly controlled with Diamox and pilocarpine 4%. The right eye which had iridencleisis at the same time is now blind
14 V. R.	F 49	O.D. 1/ 9/56	34	15	6/4	6/4	Closed above	—	Yes	Full	Two yr. This familial glaucoma was controlled medically with difficulty. Since surgery tension normal without treatment. Left shows small bleb
		O.S. 1/20/58	31	18.5	6/4	6/4	—	— 2	Yes 5	Full	
15 J. K.	M 71	O.D. 12/14/56	52	14	6/4	6/6	Closed above	Yes		Contracted	One yr. This aphakic patient has been controlled with difficulty since this op. Tonography Oct. 1956: tension, O.D., 32; facility 0.13. O.S. 27, 0.34
16 L. G.	M 60	O.D. 7/ 2/56	34	17.3	6/5	6/5	—		Yes	Full	Postcataract glaucoma normal tension 1½ yr.
17 B. A.	M 57	O.D. 4/ 2/56	37	8	6/6	6/25	—		Yes		Two yr. Glaucoma after cataract had hemorrhage into vitreous at cyclodialysis. Slowly cleared partially
18 J. D.	M 72	O.D. 12/10/56	33	20	6/8	6/8	Closed	Yes		Contracted before surgery	Tension controlled 16 mo. with 2% pilocarpine
TOTAL 22 eyes								C Rx 4	S Rx 12		Three not controlled. Three partly controlled by treatment

TABLE 2

PATIENTS FROM GLAUCOMA CLINIC

(Treated by radial cyclodialysis with scleral shrinkage: Reported by Dr. Charles Barnes)

Age Case No.	Sex Eye	Operation Date	Tension Before	Tension After	Tonogram	Gonioscope	Controlled C Rx	Controlled S Rx	Follow-up
1 J. T.	M O.D.	Reg.[1] 7/31/56	40	24	4/10/56 Po^{29} C=0.15	Narrow angle			One yr. Tension finally controlled by miotics after trephination
	O.D.	Rad.[2] 11/8/56	82	27	1/27/57 Po^{20} C=0.10		No		
Col. 60	O.D.	Treph.[3] 4/8/57	35	32	6/ 4/57 Po^{32}_{22} C=0.06/0.19				
2 J. N.	M O.D.	I.Icl.[4] 3/2/56	25	22	8/29/56 Po^{22}_{17} C=0.08/0.00	Wide angle P.A.S., O.U.	No		One yr. Tension poorly controlled by medication. 12/16/58
	O.S.	Reg. 3/7/56	43	24					
Col. 83	O.D.	Rad. 12/13/56	23	39	12/10/57 Po^{32}_{51} C=0.05/0.03		No		V. O.D. = 20/80 18; O.S. = N.L.P. 26
3 J. O. N.	M O.D.	Reg. 4/4/46				Secondary			One yr. after radial cyclodialysis, partly controlled by miotics and Diamox
	O.D.	Rad. 11/16/56	28	41	12/ 5/56 Po19 C=0.12				
Col. 60	O.D.	Rad. 3/6/57	37	21	1/10/57 Po19 C=0.12		Yes?		
4 O. S. Col. 39	M O.S.	Rad. 11/23/56	27	20	4/27/56 Po^{18}_{22} C=0.04/0.21	Open angle	Yes		One year after operation C=23/17 C=0.02/0.10 V. O.D. No L.P. O.S. = 20/30
5 W. R.	M O.S.	Reg. 9/26/56	34	24	9/ 4/56 Po^{15}_{20} C=0.07/0.08	Open angle			One yr., O.D., tension fair with miotics q 6 hr. 3/3/58 tonogram
	O.D.	Rad. 12/10/56	23	26	3/11/57				
Wh. 57	O.S.	I.Icl.[4] 12/12/56	24	28	Po^{17}_{23} C=0.08/0.04		Yes		Po^{17}_{30} C=0.06/0.10
6 Wh. 79	M O.D.	Rad. 11/14/56	29	17	11/12/56 Po^{29}_{30} C=0.05/0.04	Open angle	Yes?		One and one-half years. 3/6/58 tonogram Po^{20}_{26} C=0.06/0.08
	O.S.	I.Icl. 11/18/56	30	20					Rx Pil. 4 q 6 hrs.
7 J. T. Col. 60	M O.D.	Reg. 8/1/56	40	17			No		3 mo. Controlled with Diamox. 5 mo. and miotics after 5 mo. Trephination
		Rad. 11/8/50	82	27					
		Treph. 4/8/57	36	20					
8 C. M.	M O.D.	Icl. 11/14/56	20	14	Before 8/31/56 Po^{17}_{22} C=0.17/0.08	Open angles. No P.A.S.	Yes		One yr. Controlled by miotics and Diamox. R.E. controlled after iridencleisis
Wh. 71	O.S.	Rad. 11/12/56	29	16	After 10/ 1/57 Po^{14}_{22} C=0.37/0.16				

[1] Reg. = regular cyclodialysis. [2] Rad. = radial cyclodialysis. [3] Treph. = trephination. [4] I.Icl. = iris inclusion.

No.	Eye		Before	After	Tonogram	Gonioscope	C Rx	S Rx	Follow-up
9	F								
E. R.	O.S.	Rad. with Irid.[a] 11/9/56	29		11/ 1/56 Po^{14}_{29} C = 0.15/0.01	Wide with P.A.S.	Yes		14 mo. Pil. 2 q 6 h.
Wh. 51					2/ 5/57 Po^{17}_{15} C = 0.12/0.13				1/13/58 Po^{16}_{14} C = 0.19/0.20
10	M								
J. G.	O.D.	Reg. 5/20/55	90	75			No		4 mo. Secondary after cataract extraction. Enucleated
Wh. 69		Rad. 11/8/56	75	65					
11	M								
P. S.	O.D.	I.Icl. 1/4/57	37	18	7/21/56 Po^{34}_{39} C = 0.09/0.02	Open angle	Yes		11 mo. Pil. 3% q 6 h. Tonogram 12/18/57
Wh. 69	O.S.	Rad. 1/3/57	43	12					Po^{23}_{15} C = 0.20/0.20
12									
E. P.	O.D.	I.Icl. 1/19/57	36	21	1/ 4/57 Po^{36}_{37} C = 0.00/0.04	Open angle		Yes	8 mo. Tonogram 5/7/57
Wh. 72	O.S.	Rad. 1/17/57	37	18					No Rx Po^{25}_{20} C = 0.10/0.08
13	F								
N. R.	O.D.	8/1/55 Reg.	49R	5					Congenital cataract, secondary glaucoma after extraction. O.D., not controlled, O.S., controlled when last seen 1/3/58
	O.S.	10/5/55 Reg.	47L	50	11/ 7/57 Po^{27}_{7} C = 0.04/0.07	Secondary			
	O.D.	2/1/57 Rad.	49	35			Yes		
Wh. 10	O.S.	2/4/57 Rad.	49	10			No		
14	F								
S. M.	O.S.	12/28/57 Rad. with Irid.	36	21	12/13/56 Po^{19}_{36} C = 0.17/0.01	Secondary		Yes	One mo. Treph. 9 yr. ago not functioning. Tonogram 1/7/57
Col. 65									Po24 C = 0.9
15	M								
E. T.	O.D.	10/24/56 Reg.	46	50	6/21/56 Po^{17}_{14} C = 0.10/0.15	Open angle	No		2 mo. O.D. secondary of Ext. Cat., not controlled
Wh. 56	O.D.	12/14/57 Rad.	50	47					
16	M								
I. M.	O.D.	12/3/56 Rad.	41	0±	11/17/55 Po^{33}_{34} C = 0.20/0.07	Open	No		One mo. Tension: O.D. 0 No l.p. O.S. 9.5 20/200
Wh. 78	O.S.	12/5/56 I.Icl.	41	9.5					
17	M								
J. I.	O.S.	2/1/55 Irid.			3/ 1/56 Po^{69}_{37} C = 0.02/0.02	Narrow angle with P.A.S.	No		O.D. Absolute glaucoma, O.S. V = 20/200. Tension controlled O.S. after trephination
	O.S.	1/ 5/56 I.Icl.							
	O.S.	3/ 9/56 Reg.	37	12	3/13/56 Po^{22}_{15} C = 0.08/0.06				
	O.S.	12/11/56 Rad.	53	17					
Col. 47	O.S.	2/18/57 Treph. 5	30	12					

[a] Irid. = iridectomy.

Of 18 eyes subjected to radial cyclodialysis with scleral shrinkage. 8 controlled with Rx; 2 controlled without Rx; 8 not controlled.

in a controlled state under treatment and two required no treatment. Two eyes had an iridectomy done along with the cyclodialysis. Both were controlled, one with and one without other treatment. The eyes of this group of clinic patients were apparently in a more advanced stage of glaucoma and more difficult to deal with successfully than those of the private patients presented in Table 1.

This procedure is not offered as a substitute for the more freely fistulizing operations, as iridencleisis and trephination, but rather as a method of effectively lowering tension with comparatively little disturbance of the structure or function of the eye. It is applicable in those early cases of open-angle glaucoma not adequately controlled by a tolerable amount of medical treatment but still retaining a certain amount of natural filtration. It is too soon to conclude that these are permanent results.

Summary

A modification is described of the Allen cyclodialysis technique, consisting of the liberal application of heat along the radial scleral incision, resulting in scleral shrinkage and a fistulizing wound.

The results obtained in 22 eyes treated by this method were gratifying in a majority of the cases. In some of the eyes the fistulous tracts have remained functional for five to seven years.

The results in 18 eyes of clinic patients in a more advanced stage of glaucoma were somewhat less satisfactory.

The operation is recommended for those eyes in which the tension is difficult to control by a tolerable amount of medication and in which the natural drainage facilities are not too seriously impaired.

100 North Euclid (8).

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FURTHER RESULTS WITH NONPERFORATING CYCLODIATHERMY COMBINED WITH LIMITED CYCLODIALYSIS*

Vladimir Čavka, M.D.
Belgrade, Yugoslavia

Weve (1933) was the first to apply nonperforative cyclodiathermy in a case of hydrophthalmos. Three years later (1936) Vogt published his operation of perforating cyclodiathermy. I was among the first (Albaugh and Dunphy, 1942) to use nonperforating cyclodiathermy; my first paper on his experiences was written in 1942 and published in 1944. (Klin. Monatsbl. f. Augenh., **110**: 525, 1944).

In my first cases nonperforating cyclodiathermy was combined with anterior sclerotomy and iridodialysis. Twenty cases of primary glaucoma were operated in this manner. Later, in all cases of glaucoma, nonperforating cyclodiathermy combined with limited cyclodialysis was used (Čavka, 1951). Further results were published in 1954 (Acta Internat. Cong. Ophth., 1954, v. 2, p. 1189).

In the first 20 cases, nonperforating cyclodiathermy was performed at a distance of 2.5 to 8.0 mm. from the corneal limbus, while in all other cases, the distance from the limbus was 4.0 to 8.0 mm. Furthermore, cyclodiathermy was usually performed in the upper half of the globe. In cases in which the intraocular pressure was high, especially in cases of absolute glaucoma, I usually perform nonperforating cyclodiathermy around

* From the Ophthalmologic Clinic, University of Belgrade.

the circumference, combined with limited cyclodialysis. A detailed study of the other technical details of this operation has already been given in previous papers.

In nonperforating or perforating cyclodiathermy various authors have applied the diathermy at varying distances from the corneal limbus. Weckers (1945) in nonperforating retrociliary diathermy used a distance of seven mm. from the limbus, while Arruga applied retrociliary diathermy nine mm. from the limbus. Berliner applied cyclodiathermy five mm. from the limbus, emphasizing that this was the zone containing all the bipolar ganglion cells, which had to be coagulated diathermically, and that this fact was of special importance in lowering the increased intraocular pressure. Marr applied nonperforating cyclodiathermy at four mm. from the limbus. Castroviejo applied perforating cyclodiathermy at six to eight mm., while Safar, in cases of secondary glaucoma, applied cyclodiathermy in a zone situated three to five mm. from the corneal limbus.

It is necessary to point out some other modifications in the application of cyclodiathermy. Thiel (1943) attempted, by means of introducing a diathermic spatula during cyclodialysis, to use a diathermic current on the ciliary body with a view of lessening secretion if possible. A similar operative method was published by Diaz-Dominquez (1948) while Castroviejo, instead of using the retrociliary nonperforating method, applied retrociliary perforating diathermy which represents a combination of retrociliary and perforating cyclodiathermy.

Furthermore, some authors attempt to lower intraocular pressure by applying electrolysis to the ciliary body. Following this method Berens, Sheppard, and Duel obtained favorable results in 108 operated cases suffering from glaucoma, achieving normal intraocular pressure in 75 percent of the cases operated. By applying galvanic current, Schreck tried to lower pressure in glaucoma by applying the method of cyclo-cyclodialysis. Guerry (1944) and Kettesy (1946) carried out angiodiathermy of the ciliary arteries.

After this short review of cyclodiathermic and cycloelectrolytic operative methods, I should like to consider my own experiences with the method already mentioned, namely, cyclodiathermy combined with limited cyclodialysis. I used this method in cases of glaucoma from the beginning of 1942 up to 1957. During this period, 319 cases were operated and among them the following clinical forms of glaucoma were established:

	Cases
1. Subacute congestive glaucoma	7
2. Chronic congestive glaucoma	52
3. Glaucoma simplex	134
4. Congenital hydrophthalmos	5
5. Secondary glaucoma	69
6. Aphakia with secondary glaucoma	9
7. Absolute glaucoma	43

If the number of operated cases are considered in relation to the individual forms of glaucoma, it is apparent that the majority of patients suffered from glaucoma simplex (134 cases or 42 percent). There were 52 cases (17 percent) of congestive glaucoma; 69 cases (22 percent) of secondary glaucoma; 43 cases (13.4 percent) of absolute glaucoma; nine cases (3.5 percent) of aphakia with glaucoma; and five cases (1.6 percent) of hydrophthalmos.

First will be given the results achieved in lowering or normalizing the intraocular pressure recorded in the first postoperative period, that is six months after operation. During this time all the operated cases were checked. Table 1 gives the measurements of the intraocular pressure.

According to the results in Table 1, six months after the method of combined cyclodiathermy had been carried out, intraocular pressure had become normal in 89 percent of the operated cases. These results do not include the cases of absolute glaucoma so that, if these were also taken into consideration, the percentage of successful operations would amount 86—that is a slightly lower percentage. It may further be seen that intraocular pressure remained unchanged in only 19 cases (5.9 percent) of all the operated

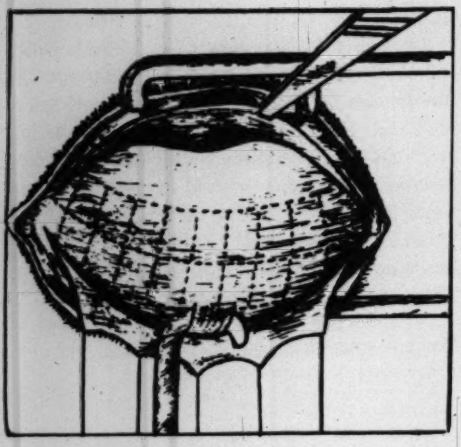

Fig. 1 (Čavka). Schematic drawing of cyclodiathermy performed four to eight mm. from the corneal limbus.

cases. It should, however, be pointed out that there were 42 cases, 14 with absolute glaucoma, in which the fall in intraocular pressure was considerable and, after operation, amounted to values of about 28 to 35 mm. Hg. However, in the cases suffering from absolute glaucoma, intraocular pressure before the operation was rather high, varying from 40 to 60 mm. Hg, so that, even though the postoperative pressure was not quite down to normal, it was considerably lowered. Further follow-up on operated cases was maintained whenever it was possible for the patients to report at the clinic. It was possible to check the following patients at the end of the second year after operation:

	Cases
Subacute congestive glaucoma	2
Chronic congestive glaucoma	21
Glaucoma simplex	52
Secondary glaucoma	39
Aphakia—glaucoma	2
Hydrophthalmos	1

In all, 127 cases were checked up two years after they had been operated. During this period intraocular pressure had increased in five cases of chronic congestive glaucoma, in two cases of glaucoma simplex, and in one case of hydrophthalmos. Patients with absolute glaucoma did not report, which probably means that after two years these patients were not suffering from any major complaints, such as pain in the operated eye or headache. It must be emphasized that during the time of follow-up the intraocular pressure was usually measured after two or three days without miotics, while in cases with intraocular pressure exceeding 22 mm. Hg prophylactic miotics were regularly prescribed.

After three years it was possible to check intraocular pressure in only 16 cases of chronic congestive glaucoma, 27 cases of glaucoma simplex, and 11 cases of secondary glaucoma. After four years intraocular pressure was checked in seven cases of chronic congestive glaucoma and in 14 cases of glaucoma simplex. At all these examinations it was established that intraocular pressure was normal. Later on further follow-up was not possible except in isolated cases. For instance, there was opportunity to check a

TABLE 1

POSTOPERATIVE INTRAOCULAR PRESSURE READINGS

Type of Glaucoma	No. Operated Cases	I.O.P. Normal	Without Miotics Normal	With Miotics Normal	I.O.P. Diminished	I.O.P. Not Diminished
Glaucoma subacute congestive	7	7	4	3		
Glaucoma chronic congestive	52	43	24	19	4	5
Glaucoma simplex	134	121	59	62	9	4
Hydrophthalmos congenital	5	4	3	1	1	
Secondary glaucoma	69	60	32	28	7	2
Aphakia with glaucoma	9	7	4	3		2
Glaucoma absolute	43	23		23	14	6
Total	319	265	126	139	35	19

patient who had had nonperforating cyclodiathermy with sclero-irido-dialysis after a period of 12 years. The operation had been performed in 1942; follow-up established that intraocular pressure in the operated eye was normal, that is, 21 mm. Hg with miotics.

What emerges from these figures is that in the course of time the number of patients reporting for a check-up gradually diminishes. For this there may be several explanations. One reason would certainly be advancing age in a large number of glaucomatous patients, making it difficult for them to travel. Another reason might well be good postoperative results and subjective satisfaction at the improvement in sight. Sickness and death must likewise be considered as reasons for the diminishing number of patients reporting for examination. However, in spite of the incomplete follow-up data it can, nevertheless, be concluded that the available follow-up intraocular pressure measurements give a fair insight and review of the efficiency of my operative method.

Analysis of visual function and the fields of vision in operated cases was only possible in part. In this series of 319 operated cases, 62 cases of secondary glaucoma must be eliminated. In these cases there was a large corneal leukoma in the operated eye with vision at light projection and possible hand movements. Here no improvement could be expected after the operation. Likewise 43 cases of absolute glaucoma should be eliminated. There remain 214 cases in which vision prior to operation was such as might be restored after operation. Improved vision was established in only 80 cases (31 percent). Vision deteriorated in 13 cases (six percent), while in 123 (57 percent) it remained practically unchanged.

In the 80 cases in which improvement of visual acuity was recorded, two were cases of subacute congestive glaucoma, 22 of chronic congestive glaucoma, 47 of glaucoma simplex, one of hydrophthalmos, seven of secondary glaucoma, and one of aphakic glaucoma. The results in improved vision and fields of vision are recorded in Table 2.

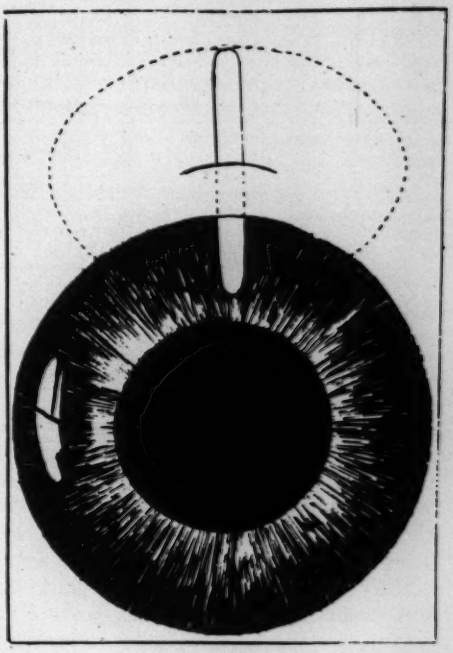

Fig. 2 (Čavka). Drawing to show technique of limited cyclodialysis, with the incision of the sclera two mm. from the corneal limbus.

Postoperative complications were recorded only during the immediate postoperative stage. They took the form of hemorrhage in the anterior chamber, which occurred immediately after operation. Minor hemorrhages were often seen in the anterior chamber but they disappeared on the day following operation. Hemorrhages which spread over one third of the anterior chamber and, in some cases, even over the whole lower half were usually found in cases of congestive or absolute glaucoma, while in cases of glaucoma simplex they were rarely found. Such hemorrhages were recorded in 33 of my cases (10 percent). As mentioned in a former work, even these major hemorrhages regularly disappeared during the 10 days following operation, leaving no unfavorable effects on the operated eye.

TABLE 2

CASES SHOWING IMPROVEMENT IN VISION AND VISUAL FIELDS

Type of Glaucoma	No. Operated Cases	Vision before Operation	Vision after Operation	Field of Vision
Glaucoma subacute congestive	2	1 c. 2/60 1 c. 1/60	1. 6/15 2. 6/60–6/36	In both cases improved
Glaucoma chronic congestive	22	In 14 cases from 2/60–6/60–6/24 In 8 cases from 6/36–6/15	In 14 cases from 6/60–6/18 In 8 cases from 6/12–6/8	In 16 cases improved
Glaucoma simplex	47	In 25 cases from 3/60–6/60 In 22 cases from 6/60–6/18	In 28 cases from 6/60–6/24 In 19 cases from 6/36–6/10	In 31 cases improved
Secondary glaucoma	7	In 7 cases from 2/60–5/60	In 7 cases from 3/60–6/36	In 3 cases improved
Hydrophthalmos	1	4/60	6/36	Slightly improved

A further postoperative complication was iritis with more or less marked hyperemia of the iris and a positive Tyndal-phenomenon recorded in 19 of my cases (5.8 percent). This complication likewise disappeared in 10 to 12 days at the most. No cases with keratic precipitates were recorded. No other deleterious effects from electrodiathermy were established in the cornea or lens nor in other parts of the eye.

Here must be mentioned the hypotension which almost regularly occurred during the postoperative period, similar to the hypotension recorded after iridencleisis (Holth), trephining of the sclera (Elliot), or any other fistulizing method. There was, however, one difference. It was observed that postoperative hypotonia, measured about eight days after the operation, amounted to eight to 12 mm. Hg. It was further observed on comparing the present operation with iridencleisis that, after my operation, hypotonia might persist for one or two months, sometimes even for six months after operation. The incidence, of such protracted hypotonia was never higher than 11 percent excepting in cases of absolute glaucoma. As to visual function, no deleterious effects on the operated eye from such protracted hypotonia of the eye were recorded during the postoperative period. Periodic application of mydriatics in such cases during the first two or three weeks showed no visible effects and the cases proved to be rather refractory to the application of one-percent atropine or one-percent homatropine. The intraocular pressure findings in such cases have been included in Table 3.

As is apparent from Table 3, postoperative hypotension appeared after all three anti-glaucoma operations. However, in Cases 3, 4, and 6, hypotension of the operated eye was more marked after cyclodiathermy. As compared with iridencleisis and trephining of the sclera, after cyclodiathermy hypotension in the operated eye was almost always more marked. This was due to combining the method of cyclodiathermy with limited anterior cyclodialysis.

As has already been mentioned, if during sclerotomy in cyclodialysis, prolapse of the iris occurs, one should immediately excise the prolapsed iris and cauterize by cyclodiathermy the remaining part of the iris before proceeding to cyclodialysis. These prolapses of the iris occurred most frequently in cases of glaucoma in which the pressure was most elevated, and especially in cases of absolute glaucoma. This could not be considered an operative complication as it had no ill effects on the operated eye.

Discussion

In considering my operation of nonperforating and combined cyclodiathermy I may say on the grounds of my observations that this is an antiglaucoma operation which may be applied in all cases of glaucoma excepting acute or subacute iridocyclitis with hypertension. Cases of acute glaucoma are likewise not suitable for this method; in all other cases of glaucoma it may be applied by performing nonperforating cyclodiathermy about four to eight mm. from the limbus either in the upper half of the eye or around the circumference. One achieves an intensive electrocoagulation not only of the capillaries and ganglion cells in the ciliary body but also of the neurosecretory elements and the retrociliary arteries. The subsequent atrophy in the ciliary body after operation is, in my method, increased by anterior cyclodialysis which also produces decreased secretion in the ciliary body. Sometimes this was especially marked, as shown by protracted hypotension in the operated eye.

This operative method proved to be successful in normalizing and lowering intra-

TABLE 3

FINDINGS IN CASES OF POSTOPERATIVE HYPOTENSION

No.	Name Age (yr.)	Year of Operation	Diagnosis	Operation	I.O.P. (mm.Hg) before Operation	I.O.P. (mm.Hg) 10 da. after Operation	I.O.P. (mm.Hg) One mo. after Operation	I.O.P. (mm.Hg) Two mo. after Operation
1	A. R. 46	1954	Glaucoma simplex, O.U.	Iridencleisis, O.D. Cyclodiathermy and C.d.c.s.,* O.S.	R.E. 43 L.E. 40	15 12	17 14	21 16
2	O. P. 67	1954	Glaucoma simplex, O.U.	Cyclodiathermy and C.d.c.s., O.D. Iridencleisis, O.S.	45 41	17 18	20 20	20 20
3	R. J. 51	1954	Glaucoma simplex, O.U.	Cyclodiathermy and C.d.c.s., O.D. Iridencleisis, O.S.	52 43	11 16	15 20	16 20
4	M. J. 53	1954	Glaucoma simplex, O.U.	Cyclodiathermy and C.d.c.s., O.D. Iridencleisis, O.S.	49 46	10 14	14 20	13 21
5	L. J. 40	1954	Glaucoma chronic congestive, O.U.	Cyclodiathermy and C.d.c.s., O.D. Iridencleisis, O.S.	45 39	15 15	20 20	20 20
6	K. R. 57	1955	Glaucoma simplex, O.U.	Cyclodiathermy and C.d.c.s., O.D. Iridencleisis, O.S.	50 45	14 16	15 19	15 19
7	K. M. —	1955	Glaucoma simplex, O.U.	Cyclodiathermy and C.d.c.s., O.D. Elliot, O.S.	51 44	10 12	16 20	16 23
8	M. L. —	1954	Glaucoma simplex, O.U.	Cyclodiathermy and C.d.c.s., O.D. Elliot, O.S.	53 46	14 16	20 23	21 24
9	R. M. 45		Glaucoma chronic congestive O.U.	Cyclodiathermy and C.d.c.s., O.D. Elliot, O.S.	40 39	19 20	21 23	22 22
10	S. J. —	1955	Glaucoma chronic congestive O.U.	Elliot, O.D. Cyclodiathermy and C.d.c.s., O.S.	36 35	15 12	20 22	20 23

* C.d.c.s. = Limited cyclodialysis.

ocular pressure in those cases of glaucoma in which the tension was very much elevated. The effect was particularly apparent in cases of absolute glaucoma in which intraocular pressure varied between 50 and 60 mm. Hg prior to operation. After operation, in certain cases, the pressure fell considerably, sometimes even to normal. It would therefore seem that this operation can be applied even in cases of glaucoma in which the intraocular pressure is high. In my opinion this operation not only should be considered as a first intervention in cases of glaucoma but also in cases in which some other operative method has been performed but failed to bring the intraocular pressure down to normal.

Summary

The postoperative results recorded in 319 cases of various clinical forms of glaucoma in which nonperforating cyclodiathermy with limited cyclodialysis had been performed are reviewed. Apart from the results achieved in respect to intraocular pressure, there are data on visual function and postoperative complications.

In these cases systematic postoperative follow-ups were made during the first year following operation. As the number of patients reporting for follow-up subsequently decreased it was not possible to record data for a longer period after operation. Intraocular pressure was seen to be normal during the first postoperative six months in 86 percent of the cases. If one subtracts 43 cases of absolute glaucoma from the 319 cases then this percentage can be considered to be 89. In the remaining 11 percent, the intraocular pressure could not be brought down to normal even with the postoperative application of miotics and Diamox.

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Višegradska ulica (25)

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TREATMENT OF SQUINT AMBLYOPIA WITH THE AFTER-IMAGE METHOD*

GUNTER K. VON NOORDEN, M.D.
Iowa City, Iowa

The treatment of squint amblyopia has made considerable progress in the last two decades. A method called "pleoptics" has been developed on the continent which is now used widely at the large eye centers in Europe and which is still relatively unknown in this country. This may be partly due to the fact that most of the original articles dealing with this subject appeared in German or French and may not have been accessible to many of our ophthalmologists.

Pleoptics was introduced at our institution during the past year and it is the purpose of this paper to give a short introduction to the principles of pleoptics, the instrumentation used, its therapeutic possibilities, and limitations.

As early as 1743 Buffon[1] recognized occlusion of the good eye to be an efficient way of treating amblyopic patients. For more than 200 years this treatment hardly underwent any variations and it is at the present time still the therapy of choice, accepted and carried out by most ophthalmologists. It was, however, noted that in certain cases occlusion, no matter how carefully carried out, resulted in either none or only minimal improvement of visual acuity. Even when eccentric fixation was diagnosed in these cases, occlusion of the sound eye was continued, or abandoned when no improvement occurred, and the case given up as hopeless. The only form of special occlusion treatment for patients with eccentric fixation, introduced more recently[2] and used with some measure of success also in our department, was the partial (temporal or nasal) occlusion of the amblyopic eye.

Although the foundation had already been laid by Comberg,[3] it was the great merit of Bangerter[4] to have introduced a new method of treating amblyopia, particularly cases with eccentric fixation, by active macular stimulation. The principle of Bangerter's method consisted in scotomization of the peripheral retina, including the area used for eccentric fixation, and subsequent stimulation by light of the macula. Once central fixation was reestablished the vision was improved by various ingenious instruments, using the senses of touch and hearing in co-ordination with visual tasks in order to improve the co-ordination between eye and brain.

Cüppers[5] developed a different method, based on after-images, which required less complicated equipment. His method has found wide acceptance throughout Europe and the foreign literature dealing with this treatment is already voluminous. We have been using the after-image method with our patients.

INSTRUMENTATION AND PRINCIPLES OF TREATMENT

The instrumentation used for the after-image method consists of the visuscope, which is used for diagnostic purposes only, and the euthyscope and co-ordinator with which the actual treatment is carried out.

By means of the visuscope the fixation behavior of the amblyopic eye can be determined. It is a conventional ophthalmoscope with a small asterisk inserted in the path of light, the image of the asterisk being seen projected on the patient's fundus. The patient is invited to fixate the target as closely as possible while the other eye is covered. It was only since the invention of the visuscope, or a slightly different instrument described by Bangerter[4] (the principle of this instrument had already been described 60 years ago by Bielschowsky[6]) that small de-

* From the Department of Ophthalmology, College of Medicine, State University of Iowa.

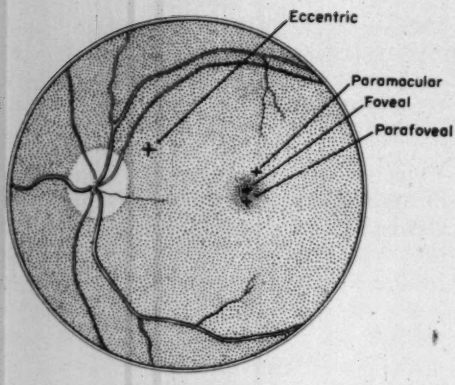

Fig. 1 (von Noorden). Fixation patterns in amblyopes (for explanation see text).

grees of nonfoveal fixation could be recognized with great accuracy. The conventional method consisting in observation of the corneal light reflex during monocular fixation is certainly not accurate enough to diagnose small degrees of eccentricity, especially in the presence of a large angle kappa.

With the visuscope fixation may now be classified to be (1) central (foveal), (2) parafoveal, (3) paramacular, (4) eccentric, and (5) wavering.

While in the first group the asterisk appears in the fovea, it may be anywhere around the fovea but within the macular depression in group two. In the third group fixation is taken up with an area adjacent to the macula. Eccentric fixators are patients who fixate with an area distant from the macula and this area may not too rarely be close or even nasal to the optic disc (fig. 1). The fifth group shows no particular preference for any nonfoveal area but performs searching movements when the eye attempts to fixate the asterisk.

The emphasis put on such an exact determination of the fixation behavior is justified when one considers that the therapeutic approach differs in each group.

Before the principles underlying the actual treatment are described, it may be worth while to consider the theoretical basis of eccentric fixation and its treatment. Actually, little is known at the present time about this interesting condition, occurring not rarely in amblyopic eyes. It should not be confused with abnormal retinal correspondence, the latter being strictly a binocular phenomenon, although both conditions may occur at the same time.

Excitation of a retinal receptor is appreciated by the visual cortex not only in terms of resolving power but also in terms of subjective projection in space. In normal eyes, the subjective principal visual direction of the fovea has the directional value of "straight ahead" and lies in the line of fixation. In some squint patients marked suppression of the fovea is present, with a corresponding loss of central visual acuity. A peripheral retinal element may in these cases possess a better resolving power than the central retinal area which is suppressed. Fixation is taken up with a retinal area close to the central scotoma and becomes thus parafoveal or paramacular.

In other cases constant stimulation of an area remote from the macula in a deviated eye may result in a change of visual directions which is maintained on monocular stimulation. Images falling on this eccentric area are localized by the patients as being straight ahead. We believe that constant stimulation of a nonfoveal point may result in its becoming the zero point or center of the occulomotor system and thus the point of orientation. We are supported in this belief by the observation that such patients invariably select the same eccentric area when the eye takes up fixation, a condition which actually suggests the development of an anomalous fixation reflex.

Whether the motor disturbance occurs as a result of the sensory anomaly or vice versa remains to be seen and will have to be investigated.

It is evident in older children from all this that occlusion of the sound eye is contraindicated when constant nonfoveal fixation is present. Such a procedure could never improve the visual acuity, because the resolving

power of any peripheral element is anatomically and physiologically limited, and, furthermore, because the undesirable alteration of the monocular visual direction would be reinforced.

The following requirements have been established by Cüppers[5] to attack nonfoveal fixation successfully:

1. Re-establishment of the physiologic superiority of the fovea over the periphery.
2. Relocation of the subjective visual direction "straight ahead" from the nonfoveal point back to the fovea.

These therapeutic conditions can be fulfilled by the after-image method combined with occlusion of the amblyopic eye before and during the intervals between treatments.

The after-image method is carried out with the euthyscope, an ophthalmoscope containing black marks of different sizes, and connected with a rheostat permitting bright illumination of the fundus. While the macula is covered by the black mark, the surrounding retina is dazzled by bright light. A negative after-image, provoked and intensified by a flashing room light, is experienced by the patient: he sees a clear spot surrounded by a ring scotoma. The negative after-image is often preceded by a positive one (figs. 2a and 2b). The clear spot corresponds to the position of the fovea which has momentarily regained its superiority over the periphery. The sensory motor co-ordination of the eye can now be trained by fixation of objects with the clear spot at distance. The sustained attention directed to the clear spot, characterizing the fovea, will enhance the recovery of its physiologic "straight ahead" localization.

The after-image method is not applicable in cases where fixation is taken up with a point close to the fovea, because even the smallest of the two black marks of the euthyscope will cover both the fovea and the adjacent nonfoveal area which is used for fixation. For treatment of these patients and of those in whom fixation has become central or nearly central after repeated euthyscope sessions, Cüppers[5] recommends the co-ordinator.

A similar instrument is known in this country as the so-called Macula Deficiency Tester (Goldschmidt[7]). They both make use of the entoptic phenomenon of the Haidinger brushes, when polarized light is thrown into the eye. The ability to see the brushes is said to be a strictly macular function (Goldschmidt,[7] Stanworth and Naylor,[8] and others). The patient, seated before

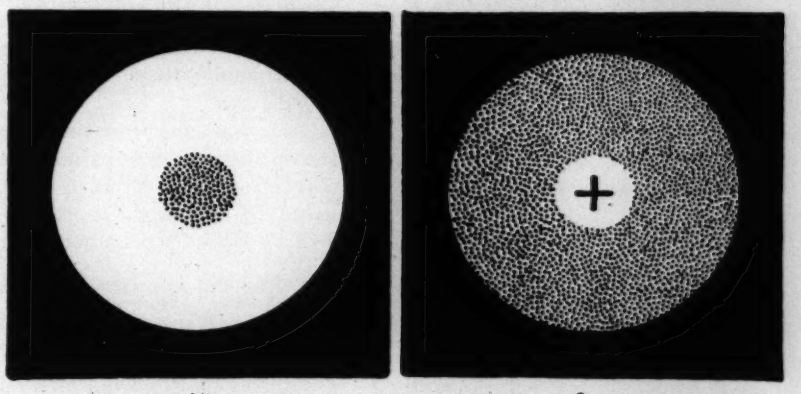

Fig. 2 (von Noorden). Subjective appearance of after-images. (a) Positive after-image. (b) Negative after-image.

the instrument, is observing the brushes and is told to direct them to a fixation object, such as the tip of a pointer which is controlled by the patient's hand. If nonfoveal fixation is present, the brushes will appear to one side of the pointer, but with concentration and effort the patient will be able to bring them to the point of fixation. Thus, according to Cüppers,[5] the cerebral coordination between eye and hand is trained.

The value of this method is obvious if one can be certain that the recognition of brushes in polarized light is strictly a macular function. We have observed repeatedly, however, that patients with extensive macular damage were able without difficulty to recognize the brushes or to determine the direction in which the filter was rotating. This observation raised some doubts whether the recognition of brushes in blue light, polarized by a rotating filter, can be ascribed to the macula alone or may not also be caused by peripheral retinal structures. The observations of Boehm[9] are interesting in this connection and the problem is being investigated by us at the present time.

Procedure

The actual procedure with our patients is as follows:

1. Diagnosis with the visuscope to determine the type of fixation. Fixation photographs with the fundus camera[10] are also taken for our records. Children with central fixation are treated in the conventional way by occlusion of the sound eye, supported by fixation exercises.

2. Parafoveal fixators are trained with the co-ordinator.

3. Paramacular, eccentric, and wavering fixators receive a preparatory constant occlusion of their amblyopic eye for a period of at least four weeks, and between treatments, until foveal fixation is re-established beyond doubt. During the actual treatment the pupil is dilated with one-percent Cyclogyl. Using the euthyscope, the macula is protected by the projected black mark, while the peripheral retina is scotomized using bright light for about 20 seconds. With the good eye covered, the patient will after a short time perceive a positive after-image in a dark room. This can be enhanced by frequent blinking of the eyelids. Using light flashes of high intensity and two or three c.p.s., the transformation into a negative after-image is accelerated, its duration prolonged, and the after-image intensified. Cüppers[5] recommends the use of a special instrument, the alternator, by which flashing light can be obtained and the light-dark ratio be regulated. We have found a Grass photostimulator to be a satisfactory substitute.

We prefer to scotomize the sound eye during the first session, so that the patient knows what to expect and will be able to appreciate the after-image better with the amblyopic eye which may cause difficulties in the beginning due to suppression.

Fixation exercises of the amblyopic eye are then carried out, beginning with fixation of close objects using the clear spot of the after-image, touching the finger tip of the examiner, and so forth. Invariably we see past pointing during these initial exercises which disappears after central fixation and the normal visual direction of the fovea have been re-established. It is our experience that visual acuity increases rapidly, as soon as fixation becomes central. Central fixation is reinforced by continued after-image treatment with fixation of simple objects at increasing distance.

The treatments are carried out preferably twice every day. Frequent examinations with the visuscope are carried out to check on the results of the treatment and fixation photographs[10] are taken for our record.

Results and Comments

Although our results have not been such as to join fully the enthusiasm of many European ophthalmologists and orthoptists, they are encouraging, and will be reported extensively in the near future. One case, however, should be reported at this time to

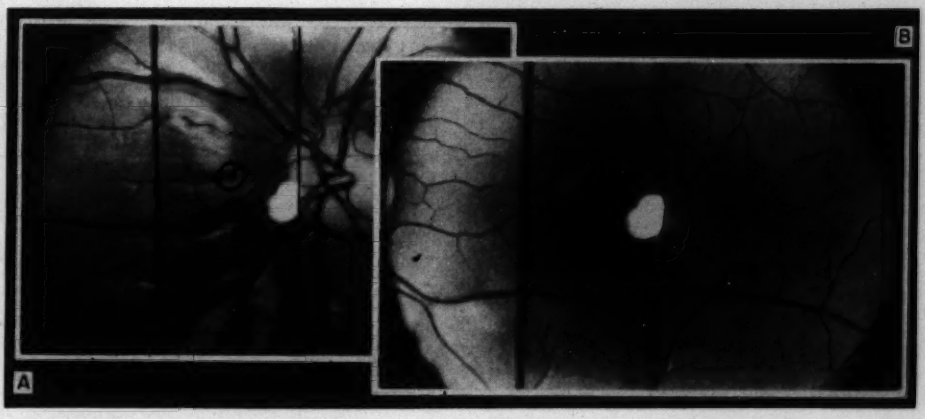

Fig. 3 (von Noorden). (a) Fixation photograph showing eccentric fixation before treatment. Note that the eye fixates with an area nasal to the disc. (b) Fixation photograph showing central fixation after treatment with after-images.

demonstrate the therapeutic possibilities of the after-image method in patients who would have to have been given up prior to the introduction of pleoptics.

An 11-year-old boy was seen in our department for the first time in 1957. His eyes had turned in at the age of two years. His visual acuity was 6/6 in the right and 3/60 in the left eye with marked eccentric fixation, O.S. His good eye had been patched by several doctors for many months prior to his first visit with us. He had a small hypermetropic astigmatic refractive error in each eye. A recession of the medial rectus and a resection of the lateral rectus were done on the left eye with good cosmetic results. His visual acuity remained unchanged.

Examination with the visuscope and fixation photography revealed that the patient preferred for fixation an area which was nasal (sic!) to the left disc (fig. 3-a). After occlusion of the left eye for four weeks, the patient received 14 treatments with the euthyscope over a period of three weeks, after which his fixation became central (fig. 3-b). His visual acuity had increased to 6/30 + 1 on the Snellen chart. He was given a patch to wear over his sound eye and returned four weeks later. His visual acuity had improved to 6/15 (Snellen chart) and to 6/12 (illiterate "E"). His fixation had remained central. He is now well aware of the fact that he can see much better holding his eye straight ahead and corrects himself when the eye threatens to return into the eccentric position. He is receiving orthoptic exercises at the present time and further improvement may be expected.

It is an interesting phenomenon that our patients invariably improved their vision more rapidly when they were tested with single optotypes. This confirms previous observations by other authors.[11] Improvement of vision, when tested with the Snellen chart, often lags behind and sometimes is not present at all.

The recognition of single letters is a less complicated visual task and the "coarsening" of the visual functions is a well-known characteristic of amblyopic eyes. Recognition and separation of groups of letters present a higher task for the visual cortex and the impairment of higher visual functions in amblyopic eyes has been pointed out in the past by Wald and Burian.[12]

It should be mentioned that there are also definite limitations to the after-image method. The dependence on intelligent subjective responses eliminates almost automatically children younger than six years. Many patients require treatment over a considerable length of time before any appreciable results are seen, while others respond readily after five or six treatments. The treatments are time consuming and require considerable effort on the part of the physician and full co-operation and alertness on the part of the patient. They require an experienced ophthalmoscopist and thus will have to be carried

out by a physician who is willing to devote considerable time to the treatment of amblyopes, unless a technician trained in ophthalmoscopy is available. At the present time the after-image method is therefore confined to the larger eye centers.

The probability of subsequent decrease of vision in the originally amblyopic eye must be borne in mind. Only in those patients in whom binocular single vision, or at least some subnormal form of binocularity or alternation, has been achieved can one hope to maintain what has been gained in vision. It is therefore desirable to undertake the treatment only when close co-operation with an orthoptist is available, since orthoptic treatment can be of great help in improving fusional amplitudes and in enforcing binocularity.

We feel, in spite of the promise held by the new method of treatment, that the old occlusion method should by no means be abandoned. No patients, however, should be occluded before it has been proven beyond doubt that central fixation is present in the amblyopic eye.

This would be true even if Parks[13] were right who recently stated that simple occlusion at an early age plus mass visual screening of all children between four and four and one-half years of age would result within one generation in such a scant number of monocular amblyopes that there would be little need for attempts to improve amblyopia later in life. As long as this is not a reality and as long as amblyopia with nonfoveal fixation in older children or even adults remains a problem for the ophthalmologist, these patients present fascinating therapeutic challenges to which we can respond now through the introduction of the after-image method.

Summary

1. The instrumentation used for diagnosis of the fixation pattern in amblyopic patients is described.

2. The theoretical principles underlying the treatment of nonfoveal fixation by means of after-images are explained.

3. The actual treatment as carried out in our department is described.

4. The case of one patient with eccentric fixation in whom fixation and visual acuity could be considerably improved by treatment with after-images is reported.

5. The therapeutic possibilities and limitations of the after-image method are discussed.

University Hospitals.

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EXPERIMENTAL PRODUCTION OF EPITHELIAL INVASION OF THE ANTERIOR CHAMBER*

ARNALL PATZ, M.D., LYDIA WULFF, M.A., AND SARA ROGERS
Baltimore, Maryland

INTRODUCTION

There have been several studies where an attempt was made to produce in animals the counterpart of clinical epithelial invasion of the anterior chamber following cataract extraction. In these experimental studies, which have been summarized by Theobald and Haas,[1] Calhoun,[2] and Perera,[3] only the implantation or pearl cyst of the iris and a small epithelial cyst of the anterior chamber have been produced. The classic picture of epithelization or epithelial downgrowth that occasionally occurs following cataract extraction has not been observed.

As part of an experimental tumor study, methylcholanthrene pellets or crystals were implanted into the anterior chamber and into the vitreous of the mouse eye. In approximately one fourth of 250 operated eyes corneal or conjunctival epithelium proliferated through the puncture wound to invade and completely line the anterior chamber or posterior part of the eye. On further evaluation it was observed that surface epithelial invasion of the anterior chamber could be produced in the mouse by the introduction of a suture into the anterior chamber. These observations suggest a new approach in the experimental study of the clinical problem of epithelial downgrowth and are the basis for this report on studies which are still in progress.

SUBJECTS AND METHODS

EXPERIMENT I

Mice of albino strains "Strong A," A/Jax, and CF_1 and black C_{57} were injected with either crystals or pellets of methylcholanthrene; 250 eyes were injected; 128 in the anterior chamber and 122 in the vitreous. Approximately equal numbers of male and female were used, ranging from two to six months of age at time of operation. The animals were anesthetized with sodium pentobarbitol intraperitoneally. No preliminary preparation of the eye was made and sterile technique was not employed.

Methylcholanthrene was packed in the tip of a No. 24 hypodermic needle of short bevel and with fitted stylet (fig. 1). Crystals of the carcinogen were used in about half the experiments; pellets formed by melting and resolidifying the crystals in the remainder.

In the majority of the operations preliminary Ziegler knife incisions were made either at the limbus (anterior chamber injections) or just posterior to the ciliary body for injections into the vitreous. The needle was inserted through this incision and the methylcholanthrene ejected rapidly by pressing the stylet. About one third of the animals were given the injection through a single puncture wound made by the packed needle with no previous incision. A Woods ultraviolet light was used to visualize the fluorescent crystals. Injection sites are shown in Figure 2.

Fifty eyes served as injection controls and were operated by the techniques outlined but no methylcholanthrene was used.

The animals were examined at intervals and killed two to 12 months postoperatively. The head was fixed in Bouin's solution and transferred to formalin at 48 hours. Serial sections of six micra were cut and stained

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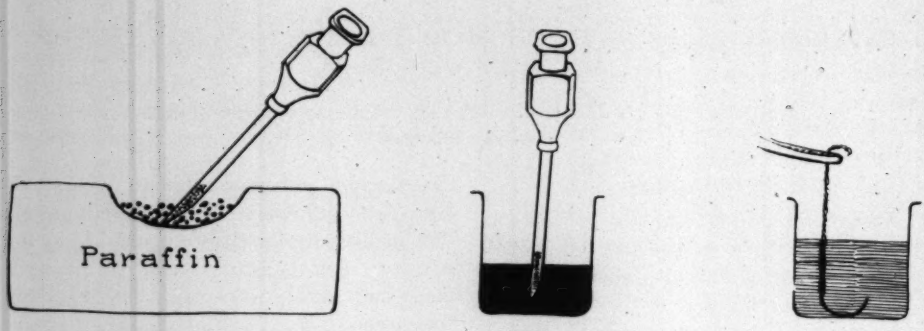

Fig. 1 (Patz, et al.) Schematic diagram showing (A) loading of pure crystals of methylcholanthrene into the needle, (B) fused methylcholanthrene crystals are introduced, and (C) a silk suture impregnated with molten methylcholanthrene.

with hematoxylin-eosin or periodic acid-Schiff stains.

Results of Experiment I

One day after operation all of the animals showed a varying degree of conjunctival hyperemia. In approximately 90 percent of the animals the injection of the conjunctiva persisted for five to seven days. When in clear cornea the puncture wound appeared as an area of corneal edema during the first week after operation. This cleared usually by the 10th day and a translucent gray scar remained at the wound site. However, in the remaining 10 percent of the animals the conjunctival hyperemia increased and the corneal edema and haze extended over the entire cornea. By the second week post-

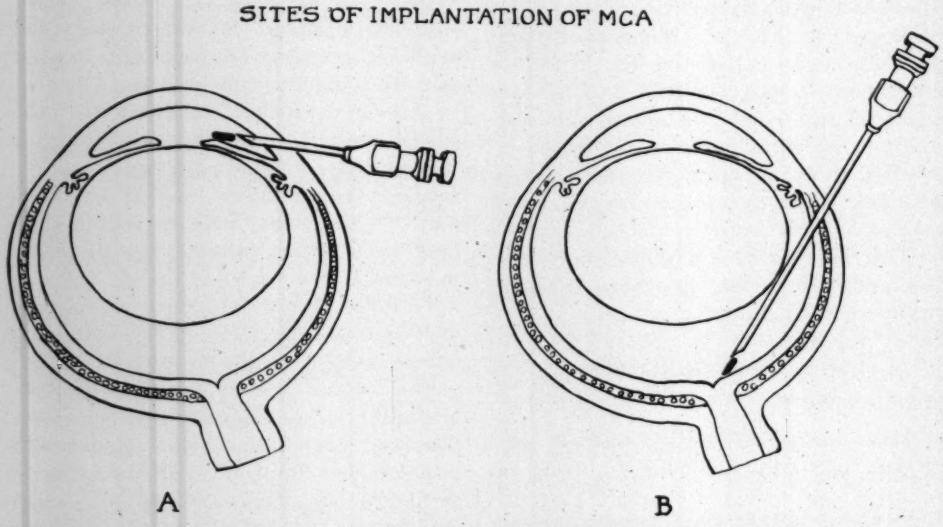

Fig. 2 (Patz, et al.) Schematic diagram showing (A) introduction of methylcholanthrene into the anterior chamber through a limbal incision and (B) showing the introduction into the yitreous through an incision just behind the ciliary body.

operatively, the globe had become shrunken and phthisical in this group.

In many of the eyes that did not become phthisical, the gray area in the cornea about the wound site enlarged so that by the third week the cornea became diffusely hazy. This was followed by a varying amount of white debris being noted in the anterior chamber (figs. 3 and 4). In section, several eyes showed that this material was proliferating ingrown surface epithelium. The methylcholanthrene fluoresced in some animals for as long as two months postoperatively, but no fluorescence was detected in animals after three months.

On microscopic examination, 62 eyes showed surface epithelium invading the interior of the operated eye. In 41 instances an anterior chamber injection had been used and in 21 the injection was made into the vitreous. Only four eyes of the 250 operated failed to develop some degree of cataract. In many eyes the needle had obviously punctured the lens capsule at the time of operation. When one visualizes the relatively large size of the lens of a mouse eye in relation to the total intraocular volume, one can readily appreciate why the lens is damaged by this procedure. A cross section of a normal adult mouse eye is shown in Figure 5. A view of the anterior segment of the normal eye at high magnification is shown in Figure 6 for comparison with the experimentally treated animals.

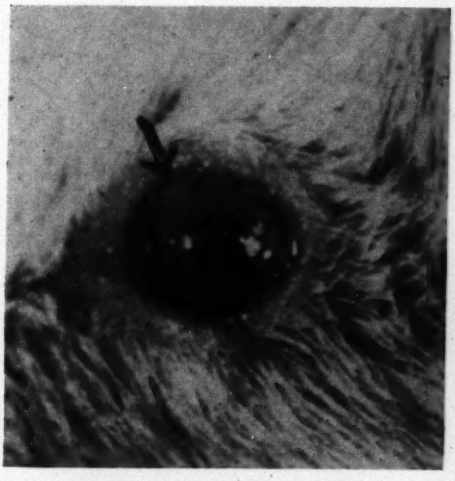

Fig. 3 (Patz, et al.). Photograph of mouse eye one month after methylcholanthrene crystals were introduced into the anterior chamber through a limbal incision. Arrow points to downgrowth of conjunctival epithelium in the anterior chamber.

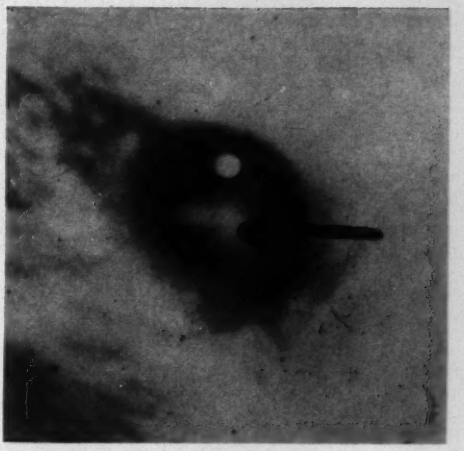

Fig. 4 (Platz, et al.). Photograph of mouse eye two months after a fused methylcholanthrene pellet was inserted into the anterior chamber through a limbal incision. Arrow points to material in anterior chamber which on section consisted of ingrown conjunctival epithelium.

Examples of surface epithelium completely lining the anterior chamber are demonstrated in Figures 7 through 10. When periodic acid-Schiff stain was used, the vacuoles of the ingrown surface epithelium appeared identical to the PAS staining vacuoles seen in the goblet cells of the conjunctiva. In six eyes a small pocket of epithelium was noted, as in Figure 7 and Figure 8. Within these cystlike pockets one could see the desquamated surface epithelium and these cells appeared quite similar to those seen in human epithelial downgrowth. For comparison, a photograph of these desquamated cells from ingrown surface epithelium in a human case of epithelial downgrowth following cataract operation is found in Figure 11.

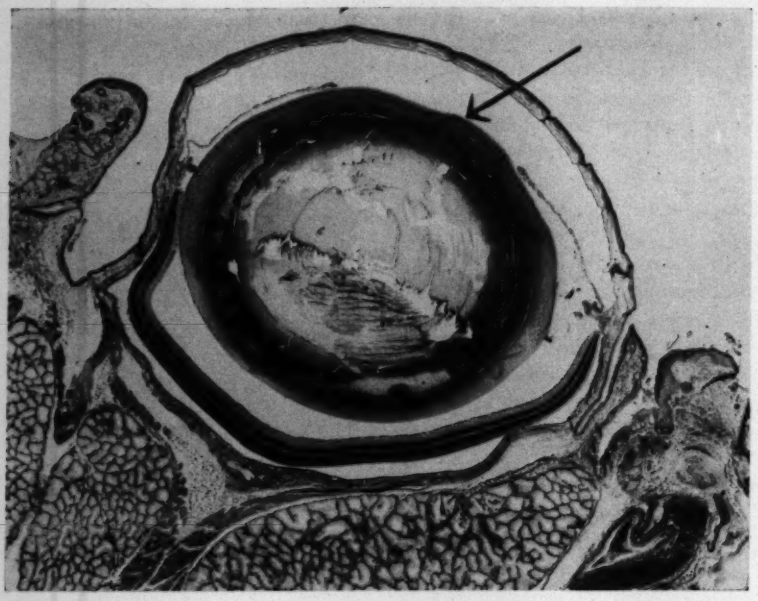

Fig. 5 (Patz, et al.). Cross section of normal adult mouse eye showing relatively large lens in this species. Arrow points to crystalline lens. (Hematoxylin-eosin, ×30.)

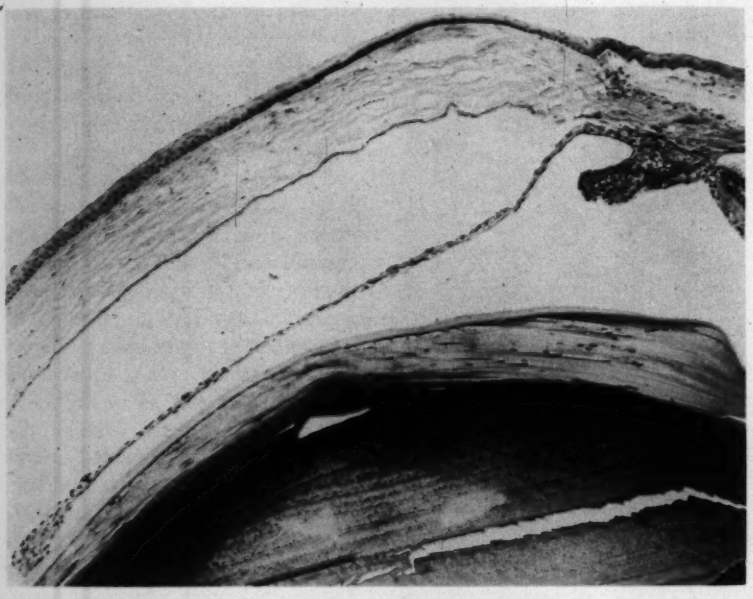

Fig. 6 (Patz, et al.). Higher magnification of normal anterior chamber angle area of the mouse eye showing the normal endothelial lining of the cornea and the relationship of the retina, ciliary body, and iris root (Hematoxylin-eosin, ×100.)

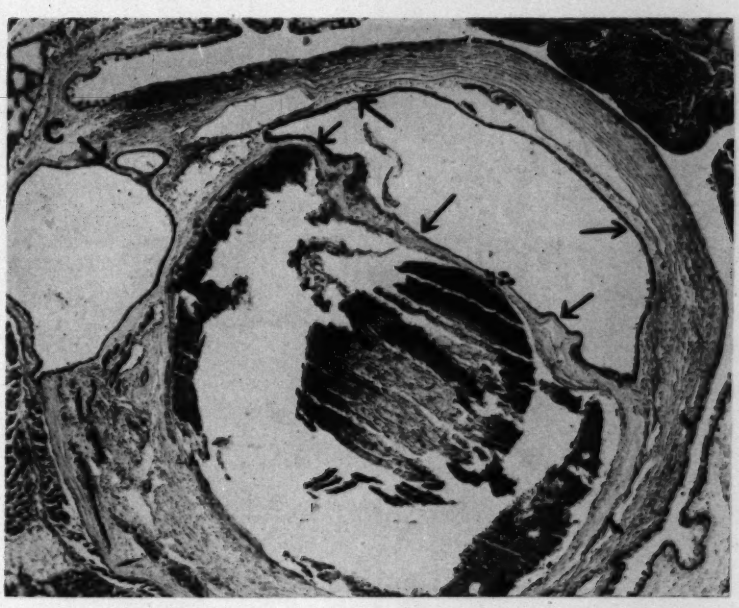

Fig. 7 (Patz, et al.). Cross section of eye of mouse injected with methylcholanthrene into the anterior chamber. Arrows point to surface epithelium lining entire anterior chamber. Note epithelial-lined cyst (C) near limbal incision. (Hematoxylin-eosin, ×50.)

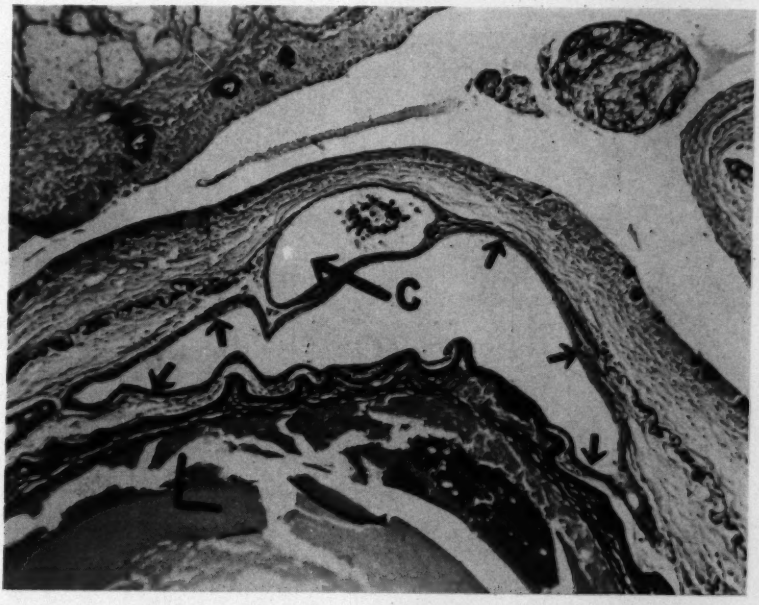

Fig. 8 (Patz et al.). Section through anterior chamber of mouse eye where methylcholanthrene was introduced through limbal incision into anterior chamber. Arrows point to surface epithelium lining entire anterior chamber. Note small cystic pocket of surface epithelium (C) invading cornea. (L) Crystalline lens. (PAS, ×100.)

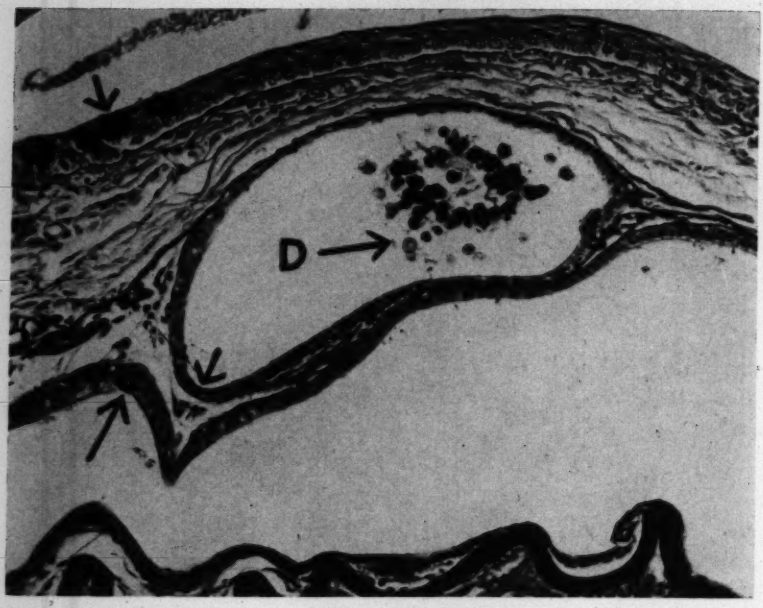

Fig. 9 (Patz, et al.). Higher power of ingrown surface epithelium. Arrows point to PAS staining material in epithelium in the anterior chamber and in limbal conjunctiva. (D) Desquamated ingrown surface epithelium. (PAS, ×200.)

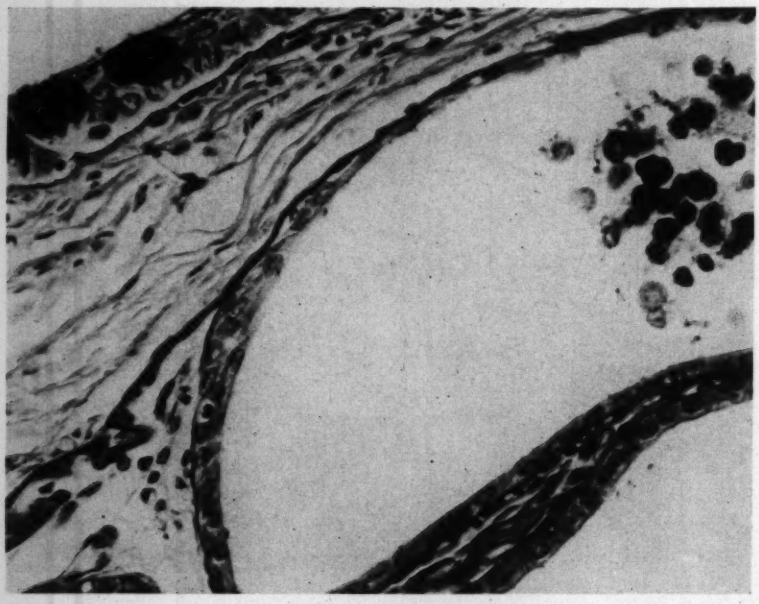

Fig. 10 (Patz, et al.). Higher power view of area seen in Figure 9 showing details of surface epithelium. (PAS, ×450.)

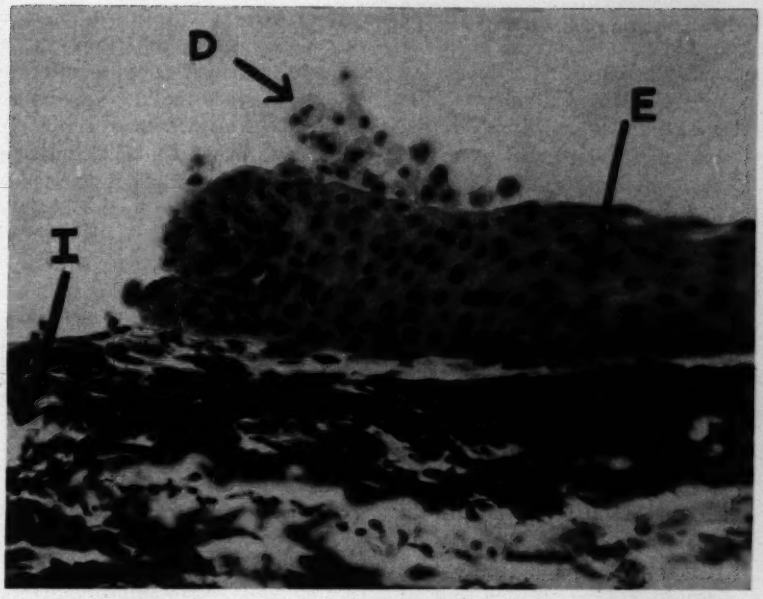

Fig. 11 (Patz, et al.). Cross section of human eye enucleated for epithelial downgrowth which caused intractable glaucoma. (D) Desquamated surface epithelial cells, (I) iris, (E) surface epithelium. Note similarity of these desquamated cells to those in Figure 9 in the mouse eye. (Hematoxylin-eosin ×300.)

EXPERIMENT II

Methylcholanthrene crystals and cholesterol crystals were mixed in a beaker and heated to their melting points. A 6-0 black silk suture on an atraumatic needle was then immersed in the molten solution and quickly removed allowing the crystals to resolidify along the suture. The needle was then introduced into the anterior chamber in clear cornea midway between the center of the pupil and limbus, passed through the anterior chamber, and out through clear cornea at about the same position on the opposite side of the cornea. C_3H mice, approximately three months of age, were used, both eyes of each animal being operated.

For controls, a 6-0 plain black silk suture not impregnated with methylcholanthrene, was introduced into the anterior chamber of C_3H animals by the identical technique.

The animals were killed one, two, four, seven, 10, 14, and 17 days after operation. One animal from the control group and one from the methylcholanthrene-operated group were killed on each of these days. Serial sections were cut at six micra in each specimen.

Results of Experiment II

In microscopic sections of the eyes examined 24 hours and 48 hours after insertion of suture into the anterior chamber either with methylcholanthrene or with the plain silk suture, the corneal epithelium had penetrated along the suture tract to the superficial stromal zone of the cornea, but no further. In the four-day postoperative specimens with plain black silk, the corneal epithelium reached the endothelial layer of the cornea and did not penetrate further into the globe. In the four-day postoperative mehylcholanthrene-impregnated suture eyes, the corneal epithelium had spread on the posterior surface of the cornea approximately halfway to the chamber angle.

The seven-day postoperative eyes with methylcholanthrene sutures showed that the

corneal epithelium extended to the chamber angle in one and stopped at the posterior lip of the wound in one. In the seven-day eyes with plain black silk, both showed that the corneal epithelium extended only to the superficial stroma of the corneal wound.

The 14-day methylcholanthrene-suture specimens showed one specimen with corneal epithelium extending to the angle and covering the peripheral half of the anterior surface of the iris. One specimen showed surface epithelium extending to the chamber angle. In the 14-day control group with plain black silk, both eyes showed no penetration beneath the superficial stroma of the cornea.

The 17-day methylcholanthrene-suture specimens showed penetration of the surface epithelium halfway to the chamber angle in one specimen and no penetration in the second. The 17-day plain silk controls showed penetration along the suture tract to the midcorneal stroma in one and no penetration in the second.

Discussion

In view of the previously reported failures to produce epithelial downgrowth experimentally, although numerous operative techniques have been employed, it was quite surprising in the methylcholanthrene-operated eyes in Experiment I that the corneal or conjunctival epithelium readily proliferated through a small needle-knife puncture wound to invade the interior of the eye. In the 58 controls where a simple puncture wound was made, epithelial invasion of the interior of the eye was not detected. All eyes in both groups were examined by serial sections. In 12 instances in the methylcholanthrene operated eyes the continuity of surface epithelium with the ingrown epithelium through the wound tract could be demonstrated (fig. 12). The possibility exists that in some instances a few cells of epithelium were carried in by the point of the needle to become implanted on the iris as occurs clinically in "pearl cysts" of the iris. No pearl cysts were seen histologically and the large number of eyes showing a tract of epithelium in the wound connecting ingrown epithelium and surface epithelium should rule out the implantation mechanism in the majority of eyes.

In Experiment II the morphologic appearance of the ingrown corneal epithelium where methylcholanthrene was used or where the simple black silk suture was used was identical in the two groups. Wolfe[4] has stated that the initial effect of the methylcholanthrenelike carcinogens appears to be

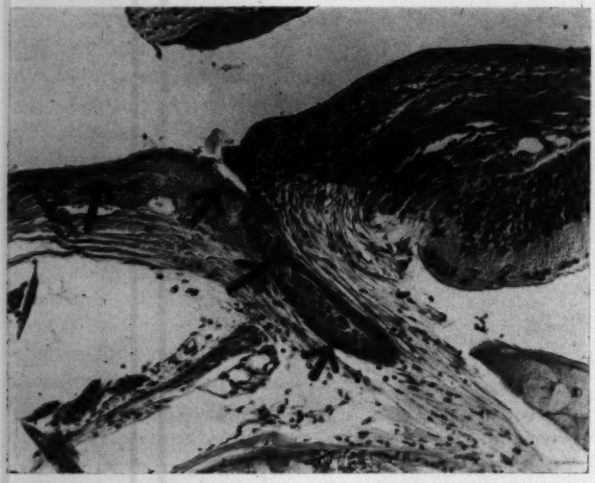

Fig. 12 (Patz, et al.). Section through a limbal puncture wound where methylcholanthrene was introduced into the anterior chamber. Arrows point to continuity of surface and ingrown epithelium. (Hematoxylin-eosin, ×100.)

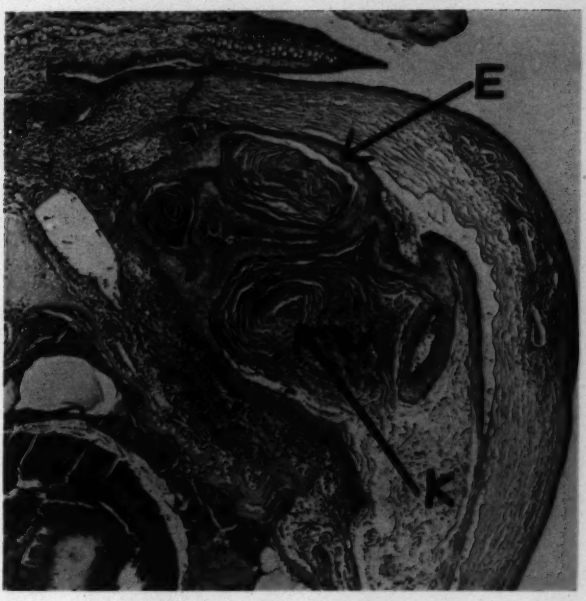

Fig. 13 (Patz, et al.). Cross section of mouse eye where methylcholanthrene was introduced into the anterior chamber. Note surface epithelial proliferation in anterior chamber (E). (K) dense sheets of keratinlike material laid down by ingrown epithelium. (Hematoxylin-eosin, ×50.)

that of a chemical irritant effect and that usually a latent period of approximately two to three months elapses before malignant transformation with tumor formation occurs (figs. 13, 14, and 15).

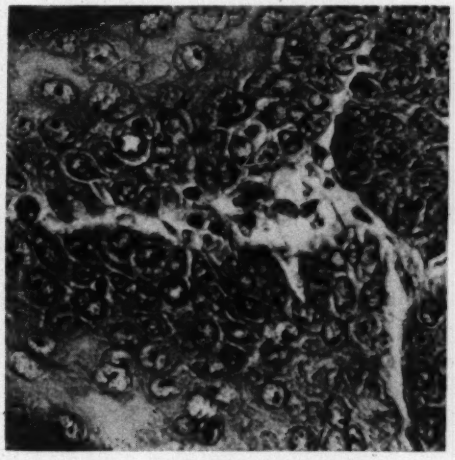

Fig. 14 (Patz, et al.). Precancerous or low-grade squamous cell carcinoma changes occurring in ingrown surface epithelium in the anterior chamber of mouse eye operated three months previously with methylcholanthrene. (Hematoxylin-eosin, ×500.)

In Experiment II when surface epithelium lined the anterior chamber within seven days, it seems unlikely that any precancerous or cancerous changes causing epithelial proliferation had been instituted. It appears more likely that we are dealing with the same type of proliferation of surface epithelium that occurred less frequently when plain black silk was used.

The technique of threading a suture through the anterior chamber has been used extensively in rabbits by Wolff[5] without epithelial invasion occurring. The production of epithelial downgrowth in the mouse in one of 16 eyes with this same technique, using plain black silk, suggests that the mouse epithelium or aqueous has special potentials for epithelization and responds somewhat like the human eye following traumatic or operative incisions into the anterior chamber.

In Experiment II there was no apparent inhibitory effect of the aqueous humor on the ingrown surface epithelium as its apparent rate of growth once the surface epi-

Fig. 15 (Patz, et al.). Arrow points to squamous cell carcinoma arising from ingrown surface epithelium in the anterior chamber of mouse eye which has spread to fill entire globe. (Hematoxylin-eosin, ×30.)

thelium reached the aqueous humor was about the same as that during its course through the oblique suture tract in the corneal substance proper.

The data obtained in Experiment II, where a plain untreated 6-0 black silk suture was introduced as compared with the methylcholanthrene-treated suture, clarify some aspects of the mechanism of epithelization in the mouse. These suture data show that methylcholanthrene increases the frequency of epithelial invasion strikingly, but it is not a necessary factor for epithelial downgrowth in the mouse eye. Epithelization occurred 11 times more frequently when the sutures were impregnated with methylcholanthrene (figs. 16A, 16B, 16C, D, and 17).

Dr. A. E. Maumenee suggested the possibility that the initial methylcholanthrene action might primarily be prevention of a snug closure of the suture tract and that other substances, such as bone wax, might act in a similar fashion. An experiment is planned to compare the effect of impregnating sutures with bone wax and with methylcholanthrene to evaluate this possibility.

When comparing the clear corneal site of

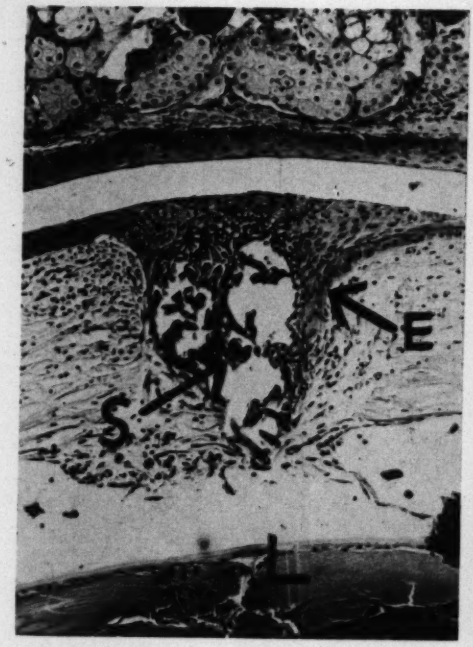

Fig. 16A (Patz, et al.). Corneal epithelium invading suture tract where a methylcholanthrene impregnated suture was introduced through the center of the cornea into anterior chamber. Animal was killed seven days after operation. (S) suture fragments. (E) epithelium. (L) lens. (Hematoxylin-eosin. ×100.)

puncture with limbal incision these data show (1) that corneal epithelium invades the anterior chamber with about the same facility as conjunctival epithelium in mice; (2) the ingrown corneal epithelium maintained its original qualities as studied with PAS stain. In no instance did a metaplasia of corneal epithelium occur, resulting in a goblet cell-like appearance or reaction to PAS stain. Where the incision was made at the limbus or through conjunctiva, as in Experiment I, the ingrown epithelium always showed the characteristic goblet cell vacuoles as seen in the parent conjunctival epithelium.

By analogy from these data one might assume that in human cases of epithelial downgrowth the presence of goblet cell activity in the epithelial downgrowth would indicate a conjunctival origin of the downgrowth.

Calhoun,[2] Perera[3] and Maumenee and Shannon[6] have stressed the importance of the clinical differentiation of (1) pearl cyst of the iris, (2) epithelial cyst of the anterior chamber, and (3) epithelial downgrowth or epithelization of the anterior chamber. It is well recognized clinically that the pearl cyst which results from an implantation of surface epithelium on the iris surface is relatively benign. The surface epithelial cyst formation of the anterior chamber, likewise, is less disastrous to the eye than a downgrowth. However, it is known to cause serious ocular sequelae when these cysts become large. Epithelial downgrowth or epithelization, however, is frequently a cause of the loss of the eye following intractable secondary glaucoma.

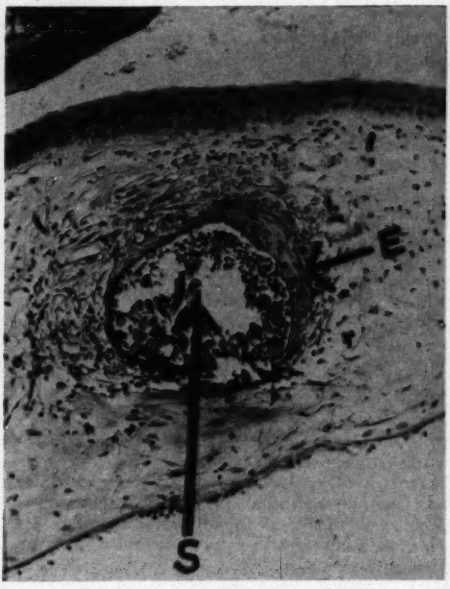

Fig. 16B (Patz, et al.). Same eye as in in 16A sectioned 72 micra deeper showing corneal epithelium in stroma about suture. (S) suture fragments. (E) corneal epithelium. (Hematoxylin-eosin, ×100.)

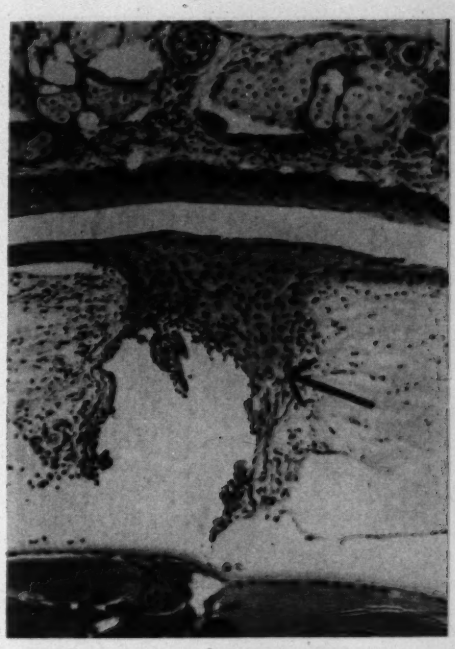

Fig. 16C (Patz, et al.). Same eye as in 16A sectioned 120 micra deeper. Arrow points to corneal epithelium. (Hematoxylin-eosin, ×100.)

The epithelial invasions in Eperiment I where the methylcholanthrene pellets or crystals were injected and the animals killed after three months were classified. No pearl cysts were noted. Twenty-four eyes showed a localized epithelial cyst filling part of the anterior chamber; 22 eyes showed a complete lining of the anterior chamber or posterior segment of the globe with surface epithelium.

Fig. 16D (Patz, et al.). Same eye as in 16A sectioned 150 micra from section seen in Figure 16A. Arrow points to sheet of epithelium (E) growing out into anterior chamber. (C) cornea. (L) lens. (S) suture remnants. (Hematoxylin-eosin, ×100.)

Fig. 17 (Patz, et al.). Section through mouse eye taken 14 days after inserting methylcholanthrene impregnated suture through clear cornea into anterior chamber. Arrows point to sheet of ingrown corneal epithelium lying behind dense anterior synechia. (C) cornea. (L) lens. (Hematoxylin-eosin, ×100.)

In 14 eyes precancerous or cancerous changes occurred in the ingrown surface epithelium after three months.

Summary and Conclusions

1. Methylcholanthrene was implanted into the anterior chamber or vitreous cavity of the mouse eye through a small puncture wound as part of a general tumor study. In approximately one fourth of the 250 eyes operated, surface epithelium proliferated through the small puncture wound to invade and frequently line the anterior chamber or vitreous space.

2. Black silk sutures were impregnated with methylcholanthrene and introduced through clear cornea into the anterior chamber and out through clear cornea. Untreated black silk sutures introduced by the identical technique served as controls. These data show that methylcholanthrene increased strikingly the frequency of epithelial invasion of the anterior chamber, but it was not a necessary factor for its production in the mouse eye.

3. The possible application of these techniques in the experimental study of the clinical problem of epithelial downgrowth is discussed.

1212 Eutaw Place (17).

Addendum

Since this paper was submitted for publication, Regan (Arch. Ophth., Nov. 1958) reported her experiments on epithelial invasion of the anterior chamber in monkeys. In addition the author presented a complete and critical review of previous experimental studies.

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THE PATHOGENESIS OF CONGENITAL GLAUCOMA*

A NEW THEORY

A. EDWARD MAUMENEE, M.D.
Baltimore, Maryland

The known congenital glaucomas should by definition include all cases of glaucoma which are the result of any ocular defect present at the time of birth. In this presentation, however, the term is used to describe only those cases in which the eyes show no obvious abnormalities other than those which are the causes of the elevated pressure. Eyes in which there are accompanying defects, such as aniridia, coloboma of the iris, hemangioma of the choroid, neurofibroma of the choroid and ciliary body, persistent hyperplastic vitreous, extensive adhesions of the iris to the posterior surface of the cornea, and so forth, will be mentioned only to the extent they may aid in determining the cause of congenital glaucoma.

There are several methods today for determining the immediate cause of an elevated intraocular pressure. These are tonography, perfusion of the anterior chamber (a procedure which has limited application), gonioscopy, and histologic examination. Each of these methods has specific advantages and disadvantages.

The accuracy of tonography is dependent at least on a steady-state of aqueous flow, a standard curvature of the cornea, and a normal scleral rigidity. All of these factors may be altered by anesthesia in a child with enlarged globes. However, repeated determinations on the same eye under the same conditions are of comparative value. Perfusion studies are most accurate when done in vivo but on account of technical difficulties have been done only to a limited extent up to the present time. In vitro perfusion studies can be done only on enucleated eyes with advanced glaucoma, or on eyes with early glaucoma obtained at autopsy, usually hours after death.

Gonioscopy is limited by the degree of resolution that can be obtained through the gonioscopic lens and by the interpretation of the observer as to the pathologic significance of the findings noted.

Histologic examination does not allow observation of the progress of the lesions and is further limited by the scarcity of eyes with early glaucoma available for examination. Both gonioscopy and histologic examination have the disadvantage of revealing morphologic and not physiologic defects.

Despite these difficulties, a review of the evidence obtained by each method strongly suggests that the cause of congenital glaucoma is a defect in the filtration angle of the anterior chamber. This report will be primarily concerned with the gonioscopy and histopathologic findings in this disease. Anderson[1] in his excellent book *Hydrophthalmia* thoroughly reviews the literature on congenital glaucoma up to 1937. Before sum-

* From the Wilmer Ophthalmological Institute of The Johns Hopkins Hospital and University. Candidate's thesis for membership in the American Ophthalmological Society, accepted by the Committee on Theses.

marizing the various findings and theories on pathogenesis he very wisely notes "Numerous difficulties arise when one attempts to summarize the reports of others concerning the findings and theories that relate to congenital glaucoma. So often a man's summing up is influenced by his own interpretations of structural defects. This might be quite different from that of another with a different viewpoint. The interpretation made by any observer may depend on his own previous training, particular interest, or the system of thought prevailing in his city or his country at the particular time when he received his training or when he is writing."

Briefly the theories listed by Anderson as to the pathogenesis are (1) an abnormality in development of the chamber angle, (2) ocular inflammation including intrauterine uveitis, (3) periphlebitis of the vortex and ciliary veins, (4) weakness of the sclera, (5) hypersecretion of aqueous as a result of a neurogenic disorder, and (6) endocrine disease.

Mauthner, in 1868,[2] is credited as the first to proclaim that congenital glaucoma was due to an elevated intraocular pressure. Bentzen and Leber,[3] in 1895, concluded as a result of perfusion studies that the cause of the elevated pressure is a defect in the filtration angle. They performed their studies on normal eyes and on an eye with advanced glaucoma which had been enucleated five minutes previously from a 14-year-old girl. Recent in vivo studies[4-6] with tonography have confirmed the findings of a lowered facility of aqueous outflow. Valude and Duclos,[7] in 1898, did goniotomies (incision of the anterior chamber angle of de Vincentiis[8]) on normal eyes of children shortly after death. They found that with this procedure the trabecula had been cut, the scleral ring or spur detached, and at times the anterior part of the ciliary body incised. More recent tonographic studies[4,5] on eyes with congenital glaucoma, done before and after goniotomy, have demonstrated that if the operation is successful the facility of aqueous outflow is increased (table 1). These physiologic studies indicate there is some block in filtration in the angle of the anterior chamber.

The majority of workers who have examined material histologically have also noted a defect in the trabecular areas. Thus Collins,[9] Cross,[10] Reis,[11] Seefelder,[12] Jaensch,[13] Meller,[14] Parsons,[15] and others have written

TABLE 1

CONGENITAL GLAUCOMA

	Tension*		C†	
	R.E.	L.E.	R.E.	L.E.
	(mm. Hg)			
710796 4 yr. WM				
Corneal diameters: R, 13 mm. L, 13.5 mm.				
Preoperative	30	15	0.00	0.00
5 mo. after several goniotomies	25	12	0.27	0.11
762461 5 mo. CM				
Corneal diameters: R, 13 mm. L, 12.5 mm.				
Preoperative	33	20	0.04	0.04
1 mo. after goniotomy R.E.	16.5	—	0.21	—
787587 1½ yr. WM				
Corneal diameters: R, 14 mm. L, 14 mm.				
Preoperative R.E.	29	—	0.00	—
2 mo. postop. goniotomy L.E.	—	24	—	0.28
4 mo. postop. goniotomy L.E. and 2 mo. postop. goniotomy R.E.	13	20	0.10	0.10

* Tension according to 1954 scale.
† C-coefficient of the facility of outflow.

extensively about such findings. Seefelder,[12,16] after a most comprehensive study, concluded that the cause of congenital glaucoma was not the same in every case. Some of the significant changes noted are as follows: (1) Abnormal persistence of the pectinate ligament, (2) backward displacement of Schlemm's canal, (3) abnormal narrowing of Schlemm's canal, (4) poor differentiation of the corneoscleral trabecula, and (5) a rudimentary development of the scleral spur. He felt that poor separation of the uveal tissue in the angle from the trabecula was the cause of these defects.

In the usual glaucomatous eye that is enucleated because of pain, advanced changes secondary to elevated pressure are evident. Therefore, most material that has been available for histologic study demonstrates either a collapsed Schlemm's canal or a very narrow one. The trabecular fibers appear to be thickened and sclerosed. Thus, although it has been clearly pointed out that Schlemm's canal is present in eyes with early congenital glaucoma examined histologically, the failure to appreciate this fact and to differentiate a collapsed canal from an absent one has promoted the concept that the absence of Schlemm's canal is one, if not the principal, cause of congenital glaucoma.

In 1928, Ida Mann[17] stated in her book on the embryology of the eye that one of the most important phases of the development in the chamber angle is the process of atrophy of the mesoderm of the iris root. In 1937, in her book on *Developmental Abnormalities of the Eye*,[18] she stated that the developmental defect in the angle which caused glaucoma was either a failure of absorption of mesoderm or in the differentiation of Schlemm's canal. In Anderson's[1] book on *Hydrophthalmia*, published in 1939, he stressed the persistence or undue development of mesodermal meshwork in the angle in congenital glaucoma. He also gave full attention to a poor development of Schlemm's canal, a posteriorly placed canal, and a rudimentary development of the scleral spur.

In 1936, Barkan[19] revived the operation of incision into the angle of the anterior chamber first proposed by de Vincentiis. He greatly improved this procedure by devising an ingenious technique of operating on the angle under direct visualization under a contact glass. In 1942, Barkan[20] reported the successful normalization of ocular pressure in 16 of 18 eyes with congenital glaucoma by goniotomy. In this article he described a gelatinouslike substance which covered the trabecula, "which corresponded in position and appearance to the persistence of fetal mesoblastic tissue that is seen in anatomic sections of the eye with congenital glaucoma." He pointed out that the removal of this material allowed aqueous to flow into Schlemm's canal, and cited the success of goniotomy as evidence that the canal was not absent in cases of early congenital glaucoma. In 1948,[21] 1949,[22] 1953,[23] and 1955,[24] he mentioned that blood could frequently be seen in Schlemm's canal in infants with early congenital glaucoma, especially after normalization of tension. Blood was also observed in Schlemm's canal in the area of goniotomy.[25] These observations of Barkan in a large series of patients convincingly proved that an absence of Schlemm's canal is not a primary cause of congenital glaucoma in most cases.

The presence of mesodermal tissue in the angle has also been observed gonioscopically by Kluykens,[26] François,[27] Scheie,[28] Weekers,[29] and others. Kluykens and Weekers believe, however, that this abnormality alone does not account for glaucoma and suggest that it is due to an attendant anomaly of the uveal vascular system.

In 1955, Barkan,[24] after reviewing his gonioscopic studies, modified his views as to the content of the chamber angle in congenital glaucoma and reported a "shagreened membrane" which covered the angle and extended downward from the line of Schwalbe over the trabecular and uveal meshwork. Associated with this on occasions there was an anterior insertion of the iris on the trabecular

fibers. His illustrations show a normal Schlemm's canal filled with blood behind this membrane.

A major contribution was made by Allen, Burian, and Braley[30-32] in 1955. In a series of three articles, they discussed the development of the angle of the anterior chamber, the ring of Schwalbe, and the pectinate ligament. They pointed out very clearly that the angle during fetal development is formed by a process of cleavage between two clearly defined groups of cells which are the anlage of the trabecular fibers on the one hand, and the root of the iris and ciliary body on the other. They also showed that the differential growth rate between the external, internal, and forward part of the ciliary body is sufficient to account for this cleavage without absorption of mesodermal tissue to clear the angle. This concept agrees with the observations of Seefelder,[16] Meller,[14] and Collins[9] but it much more clearly explains and better demonstrates this than do these previous reports.

Allen and his co-workers describe the angle in two cases of advanced congenital glaucoma. These eyes showed a defective cleavage of the ciliary body from the posterior part of the trabecular fibers. The circular muscle bundles of the ciliary body are situated far forward.

Shaffer[4]* studied the pathogenesis of congenital glaucoma from the point of view of gonioscopy and microscopic anatomy. He stated that there was an abnormally forward insertion of the iris on the trabecular fibers and a poor development of Schlemm's canal in the material studied microscopically. He also noted that in the majority of cases studied clinically, Schlemm's canal could be filled with blood and that this red band could be seen in the angle wall well above the apparent point of attachment of the iris to the trabecula. It was his opinion that the forward insertion of the iris was due to an incomplete separation of tissue during development. This abnormal insertion of iris produces a variable degree of filtration block, depending on the height of the insertion. No evidence of unresorbed mesoblastic reticulum was found filling the angle. He concluded, however, that there is a relative impermeability of the trabecula. This latter conclusion was probably based on his gonioscopic observations and the failure to find on histologic examination of some eyes any obvious pathologic changes which could account for the elevated pressure.

It may be concluded from this brief review that for approximately the past 60 years observers have consistently noted an abnormal development of the anterior chamber angle in congenital glaucoma. These changes have been variously described as persistent mesoblastic material, failure of separation of the iris and ciliary body from the trabecula, sclerosis of the trabecula, posterior position of Schlemm's canal, faulty development or absence of Schlemm's canal, and a shagreened membrane over normal trabecular fibers. While the differences in many of these abnormalities are slight, and in some instances may merely be semantic, nevertheless in other instances they indicate a real difference of opinion.

It is the primary purpose of this report to evaluate the various theories on pathogenesis of congenital glaucoma. This is done in the light of the embryologic development of the angle of the anterior chamber, the pathologic appearance and gonioscopic findings in the angle of eyes with early and advanced congenital glaucoma as compared to those of normal infants, and the effect of goniotomy in congenital glaucoma. As a result of such a study on the material available, a new theory on the pathogenesis of congenital glaucoma is advanced. This theory is also supported by observations on eyes with persistent hyperplastic vitreous, retrolental fibroplasia, and other abnormalities.

* The material reviewed by Shaffer for his report in 1955[4] was essentially the same as used in this report. Shaffer's Figure 2 is Case 2, Figure 5 is Case 3, and Figures 9 and 10 are Case 5.

Embryologic development of the anterior chamber angle

In order to understand the abnormalities observed in eyes with congenital glaucoma the embryologic development of the angle must be kept in mind. The cycle of development has been so clearly described by Allen, Burian, and Braley[31] that only a brief description of the findings at a few periods in the development will be given at this time.

In the 45- to 55-mm. embryo the anterior chamber between the posterior surface of the cornea and the anterior surface of the lens is formed and is filled with a fibrinous coagulum. The corneoscleral junction is not clearly defined. Beginning at the peripheral edge of the corneal endothelium there is a condensation of cells with a darkly stained spindle-shaped nucleus arranged in a radial fashion. These cells end posteriorly in the early condensation of the inner layers of the sclera. These cells are the anlage of the trabecula and their insertion posteriorly, the scleral spur. The meridional bundles of the ciliary muscle cannot be seen. Even at this early stage, the trabecular cells can be differentiated from the looser mesodermal tissue which will form the ciliary body and root of the iris. Red blood cells can be seen in the region that will become the deep scleral vascular plexus and Schlemm's canal. The anterior lip of the optic cup reaches only as far as the equator of the lens. The inner layer of this cup appears as retinal tissue. A sheet of mesoderm that will later participate in the development of the iris and ciliary body separates the trabecular cells and the neuroectoderm. This sheet extends a short distance into the anterior chamber.

In the 75- to 85-mm. fetus the line of the future cleavage plane between the trabecular fibers and the ciliary body can be clearly seen. The scleral spur is evident and the meridional muscle of the ciliary body can be distinguished from the trabecular fibers at the point of the beginning scleral spur. The lips of the optic cup have extended forward to the posterior surface of the iris and the retina is beginning to migrate posteriorly over what will eventually become the pars plana.

In the 140- to 160-mm. fetus the meridional muscle of the ciliary body is clearly outlined and in some instances the cells which will develop into the circular muscle bundles can be detected. The trabecular fibers measure 0.23 mm. in length. The anterior tip of the meridional muscle fibers are forward of the anlage of the scleral spur (fig. 1).

In the 220-mm. embryo the ciliary processes have formed and in some instances

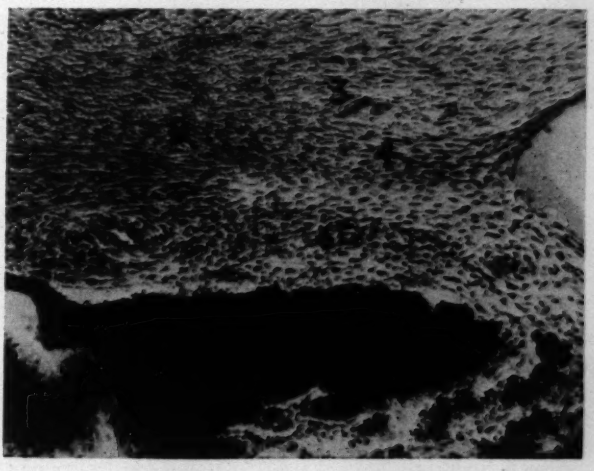

Fig. 1 (Maumenee). 150 mm. fetus. (1) Longitudinal muscle. (2) Scleral spur. (3) Blood vessel. (4) Trabecula. (5) Circular muscle. (×210.)

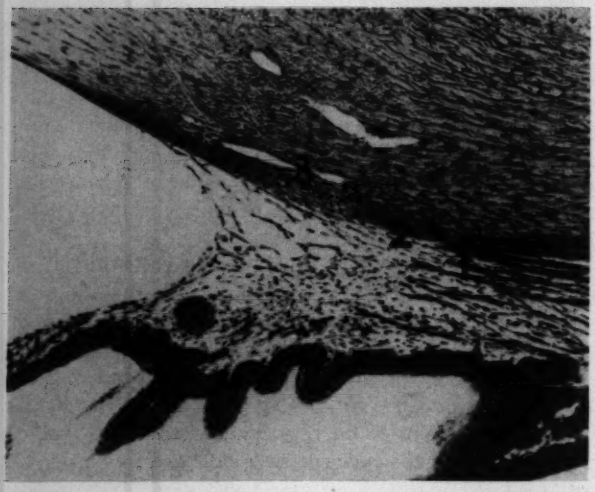

Fig. 2 (Maumenee). No. 260—seven month fetus. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

cleavage has begun between the trabecular fibers and the ciliary body. The scleral spur and meridional muscle fibers are clearly defined. The trabecular fibers measure 0.30 to 0.35 mm.

The chamber angle between the sixth and ninth month opens by a process of cleavage.* Eight apparently normal eyes of still-born fetuses between the ages of six and seven months were available for study. In only one was the angle completely open. Seven showed various degrees of attachment of the ciliary body to the trabecular processes (fig. 2). In 13 eyes of fetuses of eight months' gestation, eight eyes showed open angles and five either closed or partially closed angles. In 15 eyes of nine months' gestation, all angles were open but occasional filamentary iris processes could be seen or pectinate ligaments connecting with Schwalbe's line were present.

In 24 eyes from patients of one year of age or less the angle appeared open in all instances. The lines of intersection between the cornea and trabecula on one side and the iris and ciliary body on the other side form a more acute angle than they do in the adult. The ciliary body forms only a small part of the angle. The circular muscle of the ciliary body lies external to a line drawn perpendicularly through the posterior end of Schlemm's canal, and shows varying degrees of development.

In summary, from the embryologic point of view the angle of the anterior chamber develops by a process of cleavage rather than absorption of mesodermal tissue. The scleral spur, deep scleral plexus of blood vessels, meridional muscle, and trabecular fibers appear early in embryologic development. These structures can be noted at least by the time the embryo is 55- to 85-mm. long in crown-rump length. This is approximately the third to fourth lunar month of gestation. The final cleavage of the iris root and the ciliary body from the trabecular processes does not take place until late in fetal development. The area in which the circular muscle will develop is adherent to the trabecular fibers during this time. This final cleavage varies considerably from fetus to fetus but may occur between the 220- to 325-mm. crown-rump length fetus. This is approximately the seventh to ninth month of fetal life. The circular muscle of the ciliary body also manifests itself extremely late in the development of the fetus and is frequently difficult to find even at birth. Usually, how-

* These eyes were from a collection of Dr. Algernon B. Reese.

ver, it becomes evident during the first year of life.

Pathology of congenital glaucoma

In adult eyes, the prolonged elevation of intraocular pressure causes changes in the angle of the anterior chamber and in the ciliary body. These changes may mask the initial pathology which has caused the glaucoma. Thus in some instances peripheral anterior synechias develop in open-angle glaucoma, so that in the end-stages it may appear much like angle-closure glaucoma. Also sclerosis in the trabecular meshwork appears to be essentially the same in primary open-angle glaucoma and in long-standing glaucoma secondary to uveitis or other causes.[30] Comparable changes secondary to prolonged intraocular pressure also occur in congenital glaucoma. The interpretation of these findings in the latter cases is further complicated by the stretching of the globe. Therefore, in formulating any opinion of the pathogenesis of congenital glaucoma, it is most important to examine eyes which have not undergone extensive changes secondary to elevated pressure. Such specimens are seldom obtained and for this reason few examiners have been able to study more than one or two examples from which they draw their conclusions. This does not mean that eyes with advanced congenital glaucoma are always worthless for such study for in some instances lesions in these eyes aid in interpreting the cause of the disease and its course.

In many reports of the pathologic changes in eyes with congenital glaucoma little distinction has been made between the changes found in the eyes with early glaucoma and those in the late stages of the disease. For this reason, no attempt will be made to refer to all of the writings on pathogenesis of congenital glaucoma. Only the pertinent ones in which there are good microphotographs or drawings of the histopathology of early cases of congenital glaucoma will be cited.

In 1906, Seefelder[12] reported two cases of early congenital glaucoma. His first case was a 10-month-old girl, who at the age of three months developed signs of glaucoma, and at six months had cloudy corneas and photophobia. Her tension was not controlled by pilocarpine, and an iridectomy was done on the left eye. Three days later an iridectomy was done on the right eye. Seven days later the child was found dead in bed. The right eye only was removed for microscopic examination.

Measurements

	R.E. (mm.)
Anterior-posterior diameter	23
Horizonal diameter	22.5
Vertical diameter	21.5
Corneal horizontal diameter	13
Corneal vertical diameter	12

On microscopic examination Schlemm's canal was visible in all sections, but was considered to be smaller than normal and was posteriorly placed. The scleral spur was extremely poorly developed and difficult to distinguish from the rest of the sclera. The trabecular system bordering the anterior chamber appeared to be normal. However, the trabecular meshwork near Schlemm's canal appeared more compact than normal. The longitudinal fibers of the ciliary muscle were stated to be displaced backward from the angle of the anterior chamber. However, on examination of the accompanying microphotographs they appear to extend at least as far as the tip of the scleral spur and to insert primarily into the trabecular fibers, rather than into the scleral spur itself. The circular fibers of the ciliary muscle were poorly developed (fig. 3). The lens measured 8.5 by 1.8 mm.

The eyes of the second case were from a child seven days of age. These were given to the author, and, therefore, the clinical history was somewhat incomplete. At birth both eyes appeared very prominent and about "twice the normal size." The corneas showed diffuse central opacities. The child died after an anesthesia. Both eyes were obtained for examination.

Fig. 3 (Maumenee). Seefelder, Case 1. (C.v.) Schlemm's canal. (v.c.) Veins. (K.W.) Anterior chamber. (Sk.S) Scleral spur.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	23.5	23.5
Horizontal diameter	22	22
Corneal horizontal diameter	11.5	11.5
Corneal vertical diameter	11	11

Histologic examination. Right eye. Histologic examination showed Schlemm's canal to be present in all sections, but it frequently had a small lumen. The corneoscleral trabecular fibers appeared to be regular and had the normal number of holes. The iris was displaced toward the end of Descemet's membrane, and in many sections there were extensions from the iris which appeared to connect with Descemet's membrane. This looked much like the pectinate ligaments found in lower animals. The corneoscleral trabecula originated on a well-developed scleral spur. The circular portion of the ciliary muscle lay in front of the origin of the longitudinal muscle fibers. The ciliary processes originated from the front part of the ciliary muscle, and appeared to be stretched, glued together, and adherent to the posterior surface of the iris. Thus the angle was not normal, but showed a persistent fetal condition.

The histologic picture of the left eye is essentially the same as that in the right eye (fig. 4).

The other cases presented by Seefelder were from older children with markedly enlarged globes. Many points of similarity in the pathologic changes in the angle of the anterior chamber were found in these globes with advanced glaucoma and in the eyes with early glaucoma.

Spielberg,[34] in 1911, described the eyes of a three-month-old boy with congenital glaucoma who died the day after an anterior sclerotomy under general anesthesia.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	20	17.5
Corneal diameter	12	11

On microscopic examination both eyes are said to be essentially alike. The ciliary body was flat and pulled forward. There was also a forward displacement of the ciliary processes which were stretched to the central portion of the globe and lay close to the posterior surface of the iris. Spielberg thought that there was no persistence of the fetal pectinate ligament, but that some of the corneoscleral trabeculae had been pulled from their normal meridional plane to a radial direction into the anterior chamber. It is stated that no scleral spur or Schlemm's canal could be found. Microphotographs of this case are not included, but artist's drawings are depicted which show a fetal condition of the angle

Fig. 4 (Maumenee). Seefelder, Case 2. (K.W.) Anterior chamber. (C.v.) Schlemm's canal. (v.c.) Veins. (Sk.S.) Scleral spur.

of the anterior chamber. The measurements of the lens are not given.

Stimmel and Rotter[35] in 1912 described the eye of an eight-week-old infant who died following an iridectomy. This case had been previously mentioned by Seefelder[36] in 1910.

MEASUREMENTS

	L.E. (mm.)
Anterior-posterior diameter	18.5
Vertical diameter	19
Horizontal diameter	18
Corneal horizontal diameter	12.1
Corneal vertical diameter	11.5

The angle of the anterior chamber showed a fetal condition, with the root of the iris being inserted into the anterior one third of the trabecular fibers. Some processes from the iris appeared to extend as far forward as Descemet's membrane. The circular muscle of the ciliary body was pulled quite far forward, the scleral spur was poorly developed, and Schlemm's canal was difficult to see. There were retinal hemorrhages and evidence of an old thrombosis of the central retinal vein.

Another early case of congenital glaucoma was described by Meller[14] in 1917. This was a child who died at one week of age. He had an ectopic pupil and partially subluxated lens.

On histologic examination the right eye measured 19 mm. in the anterior-posterior diameter, and 19 mm. in the transverse diameter. The cornea was 10 mm. in the horizontal diameter. The lens measured 3.75 mm. in the equatorial diameter and 3.0 mm. thick. It was displaced temporally. The angle of the anterior chamber presented a typical fetal appearance. The ligamentum pectum is described as being dense. Schlemm's canal was visible, but smaller than normal. Although the ciliary body is described as being normal in a drawing of the histology of the circular muscle, the ciliary body is definitely displaced further forward than normal, and it also appears that the oblique and part of the

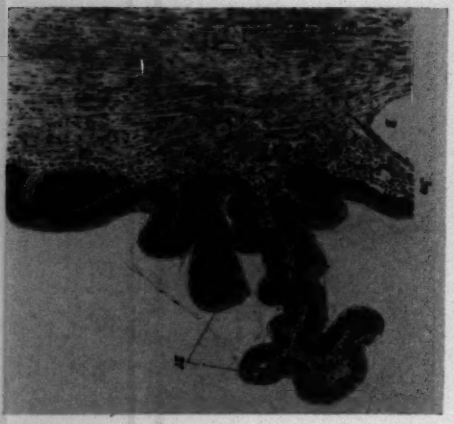

Fig. 5 (Maumenee). Meller.

longitudinal muscle fibers are inserted in front of the scleral spur. The scleral spur is rather difficult to see (fig. 5).

The left eye measured 24 mm. in the anterior-posterior diameter, and 21 mm. on cross section. The horizontal diameter of the cornea measured 12 mm. The lens was dislocated into the vitreous during sectioning, and measured 5.0 mm. in equatorial diameter and 3.0 mm. in the anterior-posterior diameter. The scleral spur was poorly developed and was located a considerable distance posteriorly from the angle of the anterior chamber. Schlemm's canal could be found, but was thin and was covered by an adhesion of the iris and ciliary body to the trabecular fibers. A drawing of this eye shows the longitudinal muscle fibers of the ciliary body inserted well in front of the anterior tip of the scleral spur, and the circular muscle bundle was also adherent to the trabecular fibers.

Another case of early congenital glaucoma was reported by Jaensch.[18] This was a child 10 months of age that had had trephinations done on both eyes. The child died after the last operative procedure.

Right eye. The scleral spur was poorly developed and Schlemm's canal could be found only in a few places. The angle of the anterior chamber showed the typical fetal form with the circular muscle of the ciliary body being inserted into the midzone of the trabecular fibers, so that Schlemm's canal and the scleral spur appeared to be posteriorly placed.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	20	21
Vertical diameter	18	20
Horizontal diameter	19	20
Corneal horizontal diameter	11	12
Corneal vertical diameter	10	12
Lens anterior-posterior diameter	2.5	
Lens equatorial diameter	6	

(The measurements of the lens of the left eye are not given, but it is described as being bean-shaped)

Left eye. The angle of the anterior chamber was essentially the same as that found in the right eye. No microphotograph of the unoperated area is depicted in this eye.

REPORTS OF CASES OF CONGENITAL GLAUCOMA PERSONALLY EXAMINED

A. EARLY CASES

CASE 1. B. C. H. 70425, autopsy 10351, E. P. 6720. The patient was a colored girl, born on December 8, 1941, two months prematurely. Her birth weight was four lb., three oz. The corneas were larger than normal and became opaque two weeks after birth. The eyes appeared to protrude, and the ocular tension was elevated to fingers. On December 19, 1941, an iridencleisis was done on the left eye. On January 5, 1942, the child died. Autopsy revealed the following: Patent ductus arteriosus, patent foramen ovale, passive congestive heart failure, acute interstitial pneumonia.

Eye pathology. Only one section of one eye is available for histologic examination (fig. 6). There are no records as to the measurements of the globe, and the histologic specimen is wrinkled so that it is impossible to get accurate measurements. Verhoeff-van Gieson stain was used.

The cornea is somewhat thicker than normal. There is a very fine filamentlike pupillary membrane extending from the collarette of the iris on either side to the posterior central portion of the cornea. The angle of the anterior chamber is open, but there has been a failure of cleavage of the root of the iris and ciliary body from the trabecular processes. The distance from the end of Descemet's membrane to the angle of the anterior chamber is 0.15 mm. The distance from the end of Descemet's membrane to the posterior recess of Schlemm's canal is approximately 0.5 to 0.6 mm. The scleral spur is bent forward and the longitudinal and oblique muscles of the ciliary body insert into more trabecular fibers than they normally do. There are approximately 12 to 13 layers of trabecular fibers

Fig. 6 (Maumenee). Case 1. (1) Meridional muscle. (2) Trabecula. (3) Schwalbe's line. (4) Iris. (×110.)

from the inner to outer surface just in front of the tip of the scleral spur. The ciliary processes come off the anterior tip of the ciliary body in front of the greater arterial circle and are pulled inward so they lie almost parallel to the posterior surface of the iris.

The remainder of the globe appears to be essentially normal. Impression: This is a case of marked forward insertion of the iris and ciliary body.

CASE 2. AFIP 331614.* The patient C. E. E. was a white girl who was born in January, 1951. While the patient was still in the nursery it was noted that she could not open her eyes except in a dimly lighted room. On examination both corneas measured approximately 13 mm. in diameter and were hazy. Gonioscopic examination was not accurate because of the cloudiness of the cornea. Under anesthesia the tension measured 45 to 50 mm. Hg (Schiøtz) in both eyes. On March 12, 1951, a goniotomy (blind type) was performed on the left eye from the 7:30- to 11-o'clock position. There was a small amount of bleeding into the anterior chamber. The child died of cardiac arrest before she was removed from the operating room.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	22	22
Vertical diameter	20	20
Horizontal diameter	20	20
Corneal horizontal diameter	13	13

(The lens was not measured)

Histologic examination of the right eye. The lens measures 6.5 mm. in equatorial diameter and 2.0 mm. in the anterior-posterior diameter in a section cut through the optic nerve and pupillary area. The lens is slightly kidney-shaped. The ciliary processes come off the anterior edge of the ciliary body more anteriorly than the scleral spur, and appear to be pulled into the center of the globe, so that they are thin and elongated. They lie almost parallel to the posterior surface of the iris. The stroma of the iris is quite thin.

The angle of the anterior chamber is of the fetal type with the root of the iris inserted into the middle third of the trabecular fibers. The longitudinal muscle of the ciliary body is quite far forward and lies well in front of the anterior tip of the scleral spur. The meshwork between the anterior surface of the iris and the trabecular fibers is quite loose (fig. 7). On one side the ciliary body contains a number of inflammatory cells consisting mostly of lymphocytes and plasma cells.

There are approximately 15 layers of trabecular fibers between the anterior surface of the iris and Schlemm's canal. The length of the trabecular fibers from Schwalbe's line to the scleral spur is 0.8 mm., and to the anterior chamber 0.4 mm. The width is 0.14 mm. The canal is definitely present in all sections, but is somewhat flattened in these preparations. The scleral spur is well developed, but is pulled anteriorly and flattened outwardly by an anterior insertion of the longitudinal and oblique muscles into the trabecular fibers. The anterior edge of the corneoscleral junction lies just over the region of Schwalbe's line.

There is a moderate posterior bowing of the cribriform plate of the optic disc. The remainder of the eye appears entirely normal.

Summary. The angle shows a fetal type of formation with failure of separation of the root of the iris and circular muscle of the ciliary body from the trabecular fibers. The longitudinal muscle is in front of the scleral spur and the ciliary processes are greatly elongated and pulled to the central portion of the globe.

* This case is reported with the kind permission of Dr. J. Thomas Schnebly, Dr. F. C. Costenbader, and Capt. W. M. Silliphant of the Armed Forces Institute of Pathology.

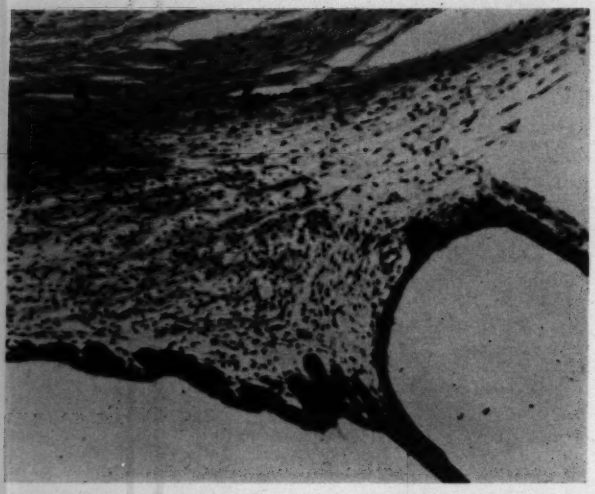

Fig. 7 (Maumenee). Case 2, R.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

Left eye. On histologic examination of the left eye the lens measures 6.2 by 2.0 mm. The length of the corneoscleral trabecula from Schwalbe's line to the angle of the anterior chamber is 0.45 mm. The lens is kidney-shaped. The ciliary processes attach to the anterior tip of the ciliary body, central to the tip of the scleral spur on the unoperated side of the eye. The processes are thin and are pulled centrally, running almost parallel to the posterior surface of the iris. On one side a goniotomy has been done (fig. 8). This has detached the root of the iris and the circular muscle of the ciliary body from the corneoscleral trabecula, and has formed an artificial scleral spur about 0.3 mm. behind the posterior edge of Schlemm's canal.

Schlemm's canal is open and contains blood on this side. The thickness of the corneoscleral trabecular fibers on the operated side is 0.04 mm., on the unoperated side it is approximately 0.1 mm. The unoperated side contains approximately 15 layers of trabecular fibers. There are a few red blood cells in the anterior chamber and *also many red blood cells fill the trabecular meshwork up to Schlemm's canal* on the unoperated side (figs. 9 and 10). There are more red blood cells in the posterior part of the trabecula than in the anterior. Only an occasional red cell is found in Schlemm's canal, and there is no hemorrhage in the ciliary body. The

Fig. 8. (Maumenee). Case 2, L.E., site of goniotomy. (1) Longitudinal muscle. (2) Artificial scleral spur. (3) Schlemm's canal. (4) Goniotomy incision. (×110.)

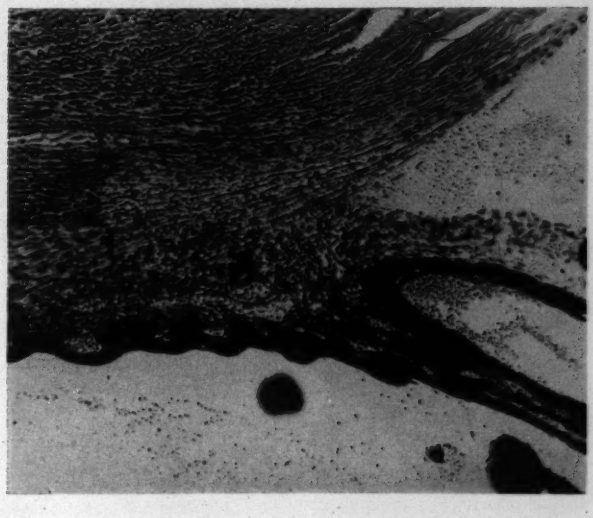

Fig. 9 (Maumenee). Case 2, L.E. Note red blood cell between the trabeculae. (1) Longitudinal muscle. (2) Scleral spur. (3) Circular muscle. (×110.)

external margin of the limbus lies just over Schwalbe's line. The iris is somewhat thin and atrophic, and the blood vessels appear to be slightly more prominent than normal.

There is a mild cupping of the cribriform plate, but the remainder of the eye appears to be entirely normal.

Impression. Despite the fact that there was a definite anterior adhesion of the ciliary body to the trabecular meshwork this did not produce a complete block of the trabecular area, for if red blood cells could pass into this region, certainly aqueous could pass into this region also.

Fig. 10 (Maumenee). Case 2, L.E. (1) Trabecula with red blood cell enmeshed. (3) Cornea. (×725.)

CASE 3.* 525 and 526, L. W. This Negro boy was born in July, 1949. On September 5, 1949, the mother noted the baby's eyes were blue. The patient was admitted to the hospital, and on September 7, 1949, under general anesthesia the ocular tension measured—right eye, 42 mm. Hg; left eye, 33 mm. Hg (Schiøtz). An Elliot trephination was done on the right eye. The child died on September 19, 1949.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	21.5	21
Horizontal diameter	21	20
Corneal horizontal diameter	13.5	11.5
Corneal vertical diameter	12.5	11

Histologic examination. Right eye, 526. The globe was cut in a vertical plane. In a section passing through the pupillary area and the optic disc the equatorial diameter of the lens is 6.5 mm. and thickness 1.7 mm. From Schwalbe's line to the posterior edge of the scleral spur measures 0.75 mm., and from Schwalbe's line to the angle of the anterior chamber measures 0.45 mm. The width of the trabeculae was 0.08 mm., and about 15 layers of trabecular fibers can be counted.

The ciliary processes arise from the anterior edge of the ciliary body just about at the apex of the scleral spur. The ciliary processes run almost parallel to the posterior surface of the iris. The lens is kidney-shaped. The iris has normal stromal thickness and architecture. On the unoperated side the root of the iris inserts into the anterior tip of the posterior one third of the trabecular fibers.

* This case is reported with the kind permission of Dr. F. Phinizy Calhoun.

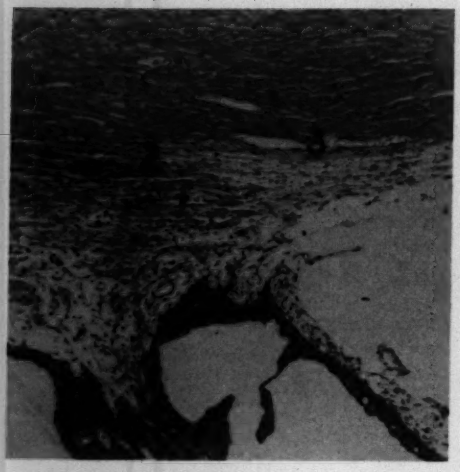

Fig. 11 (Maumenee). Case 3, R.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

This is just in front of the anterior edge of Schlemm's canal. Schlemm's canal is easily visible. The scleral spur is well developed, but is bent forward.

The longitudinal and oblique fibers of the ciliary muscle insert primarily into the corneoscleral trabecular fibers in front of the anterior tip of the scleral spur. The trabecular fibers are not thickened or sclerosed (fig. 11).

The deep scleral plexus of blood vessels appears to be normal. On the opposite side the angle is essentially the same, except that an iridectomy has been done. In the midportion of the cornea Descemet's membrane has been ruptured and curled inward on each side of the ruptured area. There are a few inflammatory cells consisting of mononuclear and polymorphonuclear leukocytes in the region of the ciliary body on the operative side. Otherwise the eye is entirely normal. There is no evidence of cupping of the cribriform plate of the optic nerve. No red blood cells were found in the anterior chamber or trabecular meshwork.

Summary. The angle of the anterior chamber is of the fetal type. Schlemm's canal was present and patent. The scleral spur has been pulled forward. The muscle of the ciliary body inserted into the trabecular fibers in front of the scleral spur. The ciliary processes were elongated and pulled into the central portion of the anterior chamber. Iridectomy has been done on one side of the globe.

Left eye, 525. The globe was cut in a horizontal plane. Histologic measure of a section that passes through the pupillary area and the optic nerve shows the length of the trabecular fibers from Schwalbe's line to the angle of the anterior chamber to be 0.5 mm. The width of the trabecular fibers just in front of Schlemm's canal as far posteriorly as they can be distinguished from the iris fibers measures 0.10 mm. There are approximately 15 layers of corneal-scleral trabecular fibers in this area, counting from the anterior chamber to Schlemm's canal.

A line drawn vertically through the posterior edge of Schlemm's canal passes through the greater arterial circle of the iris and through the base of the ciliary processes. The ciliary processes are central to this line. The anterior tip of the oblique and longitudinal muscles are also central to this line. The lens is dislocated into the vitreous, probably an artefact.

The ciliary processes are quite elongated and are pulled to the central portion of the eye. They arise off the anterior tip of the ciliary body and run parallel to the posterior surface of the iris. The iris itself is of normal structure and thickness. The root of the iris inserts into the anterior tip of the posterior third of the trabecular fibers. The longitudinal and circular muscles of the ciliary body insert into the trabecular fibers in front of the anterior tip of the scleral spur. Schlemm's canal is patent and visible in most sections, and the trabecular fibers are not sclerosed (fig. 12). The external edge of the anterior lip of the limbus is located just in front of Schwalbe's line.

The remainder of the eye appears entirely normal. There is no posterior bowing of the cribriform plate.

CASE 4*. 236-237. This patient has been previously reported by Dr. Robert L. Young.[37] The history as abstracted from this report is as follows: S. H. was a premature female infant whose birth weight was five lb., five oz. At three months of age the patient was admitted to the Michael Reese Hospital because of a failure to gain weight. On examination at that time, the child was described as a happy responsive infant but grossly undernourished and pallid. Both eyes appeared to be proptosed, the left more so than the right. There was a rasping systolic murmur heard over the entire precordial area. This murmur was found to be due to a transposition of the great vessels of the heart and an interventricular septal defect. The child also had a ventral hernia, acute pyelonephritis, possible hydrocephalus, and congenital deafness.

Ophthalmic examination revealed the left eye to be more prominent than the right. The palpebral fissure on the right side measured 9.0 mm., the left 11 mm. The scleras were pale white. The corneal diameter was estimated as 11 mm. in the horizontal plane of the right eye, and 13 mm. in the left. Both corneas were clear. The anterior chambers were deep. The irises were blue-gray. The pupils reacted readily to light. The media were clear. The fundus was well visualized and the discs were thought to be normal in color and cupping. There was some peripapillary choroidal atrophy. The vessels were normal and no hemorrhages or exudates were seen.

* This case is reported with the kind permission of Dr. Robert L. Young and Dr. William F. Hughes.

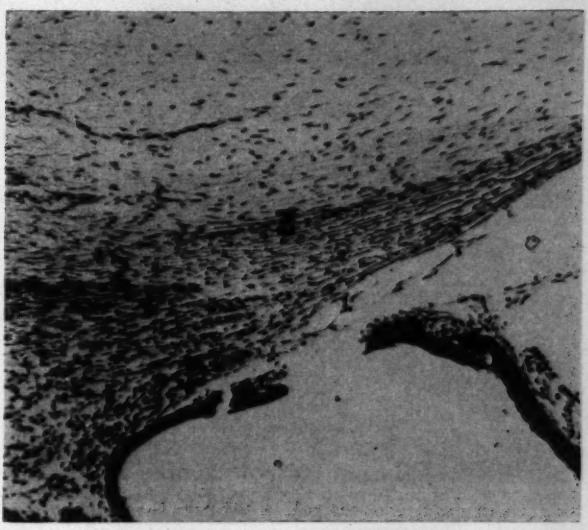

Fig. 12 (Maumenee). Case 3, L.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

Tension was recorded as 34 mm. Hg in the right and 39 mm. Hg in the left (it was not mentioned that this was done under general anesthesia, so presumably it was done under topical medication). The child was thought to have bilateral congenital infantile glaucoma, more marked on the left than on the right. She was placed on miotic therapy. Her general health improved and she was discharged from the hospital after a week of chemotherapeutic measures. Nine weeks later she was admitted to the hospital for glaucoma surgery. Her temperature suddenly rose to 105.6°F. The child died the next day. Postmortem examination revealed a situs inversus of the heart and an interventricular septal defect. The pulmonary artery was hypoplastic. There was right ventricular hypertrophy and dilatation. The child's death was due to interstitial pneumonitis.

The eyes were removed for pathologic study and sent to the Eye Department of the University of Illinois. The measurements of the globe were as follows:

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	21	22.25
Horizontal diameter	20.5	20
Vertical diameter	20.5	20.5
Corneal horizontal diameter	11.75	12
Corneal vertical diameter	11.25	11.5

Right eye, 236. Examination of the histologic specimen reveals that the globe had been somewhat distorted in fixation so that there was a marked artefactual indentation of the globe at the limbus in each eye. The lens was dislocated forward but this appears to be an artefact.

Microscopic examination. The lens measures 7.0 by 1.7 mm. The length of the corneoscleral trabecular fibers from Schwalbe's line to the posterior tip of the scleral spur is 0.65 mm. The length of the fibers from Schwalbe's line to the angle on one side is 0.7 mm., on the others it is 0.6 mm. The thickness of the trabecula is about 0.07 mm. There are approximately 15 layers of trabecular fibers between the aqueous and Schlemm's canal. These fibers are of normal texture.

The ciliary processes do not appear to be pulled inward very greatly, but this may be due to the artificial indentation of the limbus in fixing. The iris is slightly thinner than normal, but is of good texture. It arises from the ciliary body. The circular muscle of the ciliary body is well developed. Schlemm's canal is easily seen on either side of the eye. The deep scleral plexus of vessels is normal.

The most abnormal finding is the great number of the longitudinal and oblique fibers of the ciliary muscle that insert into the trabecular fibers. These come forward to about the posterior edge of the scleral spur on either side (fig. 13). The scleral spur is present but is collapsed externally. Examination of the remainder of the globe is entirely normal. There is no posterior bowing of the cribriform plate.

Impression. The only abnormal variant in the angle was a large number of longitudinal and oblique muscle fibers which inserted into the trabecular fibers rather than into the scleral spur. The scleral spur was bent forward and outward.

Left eye, 237. The lens measures 7.0 by 1.9 mm. in a histologic section cut through the pupillary area and optic nerve. The trabecular fibers from Schwalbe's line to the posterior tip of the scleral spur measure 0.65 mm., from Schwalbe's line to

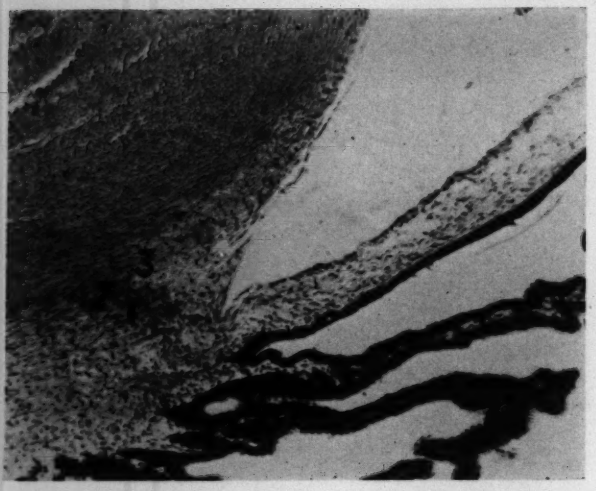

Fig. 13 (Maumenee). Case 4, R.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

the angle of the anterior chamber is 0.45 mm. The thickness of the trabecular fibers is 0.07; about 12 layers of trabecular fibers are present between the anterior chamber and Schlemm's canal.

The appearance of this eye is also distorted by a fixation defect which causes indentation of the globe at the limbal area on both sides. The lens is kidney-shaped. The ciliary processes are quite thin and arise from the anterior portion of the ciliary body and posterior surface of the iris. These arise just about at the level of the anterior tip of the scleral spur. The anterior chamber is somewhat collapsed because of the artefactual displacement of the lens. The circular muscle of the ciliary body inserts into the trabecular fibers up to about the anterior edge of the posterior one fourth of the trabecula. The longitudinal and oblique muscle fibers insert into the trabecula in front of the tip of the scleral spur (fig. 14). The spur itself is bent forward and externally so that it runs in the same direction as the trabecular fibers. The greater arterial circle of the iris lies centrally to the tip of the scleral spur. The iris is slightly thinner than normal, but the mesodermal mesh shows no other abnormality. The remainder of the globe appears entirely normal, and there is no posterior bowing of the cribriform plate of the optic disc.

Impression. The circular muscle of the ciliary body is attached to the posterior one fourth to one fifth of the trabecular fibers—although this is not sufficient to block mechanically much of filtration, it is a typical finding of eyes with congenital glaucoma. It is interesting that the left eye is larger than the right, and the forward insertion of the muscle is more marked in this eye.

CASE 5.* 215823, E. P. 918. When first seen in the eye clinic on October 2, 1953, the patient was eight and one-half months of age. The family had been requested to bring the child in for examination because an older brother had congenital glaucoma. On the first visit the tensions were recorded in the right eye as 38 to 40 mm. Hg, and the left eye as 38 to 40 mm. Hg (Schiøtz), under local anesthesia. The corneal diameters in the horizontal meridian were estimated as 11.5 mm. in each eye. The patient was placed on one drop of 0.1-percent dihydrofluoroproprionate every 24 hours. The child then developed an acute otitis media which cleared after a few days of therapy.

On November 11, 1953, he was admitted to the hospital where, under general anesthesia examina-

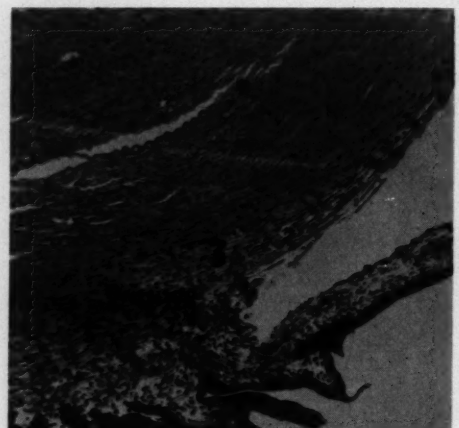

Fig. 14 (Maumenee). Case 4, L.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

* Cases 5 and 6 are reported with the kind permission of Dr. Leonard Christensen.

tion, the corneas were found to measure 12 mm. in each eye. Tension was 30 to 35 mm. Hg (Schiøtz) in each eye. Biomicroscopic examination revealed a pannus superiorly in each cornea, approximately two-mm. wide. The irises were flattened and there were no contraction furrows. The anterior chamber was normal in depth and the media were clear. The fundus appeared normal. On gonioscopic examination the last roll of the iris appeared to be adherent to Schwalbe's line. The patient was thought to be an excellent candidate for goniotomy and this operative procedure was carried out several days later. A goniotomy was done on the right eye, during which the child developed a cardiac arrest. He died several days later on November 17, 1953. Both eyes were removed at autopsy.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	24	23
Transverse diameter	24	23
Corneal horizontal diameter	13	13
Corneal vertical diameter	12	11

Right eye, 918. *Histologic measurements* of a section through the pupil and optic nerve showed the lens to be 7.0 by 2.0 mm. The length of the trabecular fibers was 0.75 mm. The distance of Schwalbe's line to the chamber angle was 0.6 mm. The corneal trabecular fibers varied in number from slide to slide from approximately 12 in some slides to 18 in others. The site of goniotomy can be found on one side and the puncture wound where the knife had penetrated the cornea on the opposite.

The iris appears to be of approximately normal thickness and structure for an infant of this age. The lens is oval. The angle of the anterior chamber on the unoperated side shows a normal deep scleral plexus of blood vessels. Schlemm's canal is patent and open.

The trabecular fibers enmesh a great number of red blood cells up to Schlemm's canal. There is no hemorrhage in the ciliary body or iris. The trabecular fibers do not appear to be sclerosed or thickened. The scleral spur is well formed, but points anteriorly more than normal. The longitudinal, oblique, and radial muscle fibers appear to insert into a few more trabecular fibers than is ordinarily seen, but in many sections these fibers do not come forward past the base of the scleral spur.

The ciliary processes appear relatively normal and arise from the anterior end of the ciliary body. They run parallel to the posterior surface of the iris but are not stretched or elongated. On the opposite side a goniotomy has been done. In several sections the goniotomy cuts through the trabecular fibers and into Schlemm's canal and the sclera. In others the corneoscleral trabecular fibers are uninjured, but the uveal trabecular fibers are removed and the longitudinal and oblique muscle fibers are detached from the trabecular ligaments in front of the scleral spur.

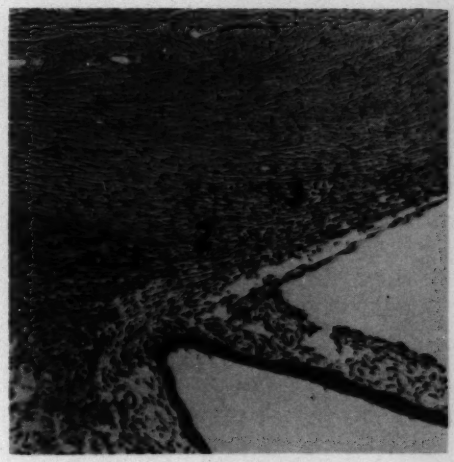

Fig. 15 (Maumenee). Case 5, L.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

The remainder of the eye appears entirely normal. There is no posterior bowing of the cribriform plate.

Impression. A specific diagnosis of congenital glaucoma cannot be made on the microscopic examination of this eye. The only questionable abnormal finding was the marked number of oblique and longitudinal muscle fibers that inserted into the trabecular network. The trabecula was freely permeable to red blood cells up to Schlemm's canal.

Left eye, 918. Histologic measurements of a section which passes through the pupil and optic disc show the lens to measure 8.0 by 2.0 mm., the trabecular meshwork 0.75 mm., and from Schwalbe's line to the angle of the anterior chamber is 0.8 mm. The thickness of the meshwork is 0.07 mm., and there are approximately eight to 12 layers of fibers between the anterior chamber and Schlemm's canal. The deep scleral plexus of blood vessels seems to be present and normal.

The ciliary processes are elongated and arise from the anterior tip of the ciliary body. They are parallel to the posterior surface of the iris. The lens is oval in shape. The iris stroma appears to be of normal thickness and structure. In most sections the angle on one side appears to be entirely normal, except for an occasional iris process, which runs from the anterior surface of the iris to Schwalbe's line (fig. 15). On the other side of the angle there is an iris adhesion to the posterior one fifth of the trabecula. The longitudinal muscle bundle inserts into a well-developed scleral spur. There is not an excessive number of meridional or oblique muscle fibers attached to the trabecular fibers. Schlemm's canal is narrowed, but is definitely present in most specimens. Examination of the remainder of the eye shows the retina, choroid, and

sclera to be entirely normal. There is no posterior bowing of the cribriform plate.

Impression. A diagnosis of congenital glaucoma could not be made on histologic examination of this slide. The only abnormality found was an adherence of the iris root to the posterior sixth of the trabecular fibers in some sections.

CASE 6. 230134, E. P. 1095 and 1096. This male child was first seen in the eye clinic on February 10, 1955, at which time a history of epiphora and clouding of both corneas for a period of three months was obtained. Apparently this condition had not been noted at birth, nor had it been noted when the pediatrician examined him at the age of four months. The glaucoma did not respond to miotic therapy. The patient was, therefore, referred to the University Hospital for surgical treatment.

The child was nine months of age when first seen in the eye clinic. The pupils were three mm. in diameter. The anterior chambers were deep. The corneas were cloudy and measured 11 to 12 mm. in the horizontal meridian. The tension under general anesthesia measured 32 mm. Hg in the right eye and 37 mm. Hg (Schiøtz) in the left eye. Because of these findings the patient was admitted to the hospital for surgical treatment of his congenital glaucoma. On February 11th, under general anesthesia, the tension in both eyes was again elevated. An anterior sclerotomy and iridectomy were performed on the right eye. During the postoperative period the patient developed a mild fever and chills due to a gastro-enteritis.

On February 19th, the right eye showed the cornea to be clear. There was minimal postoperative reaction. The left eye was somewhat softer than on admission and the cornea had cleared considerably. On February 25, 1955, the child was anesthetized again in preparation for an operation on the left eye. He developed a cardiac arrest. Thoracotomy and massage were performed immediately and calcium chloride injected intraventricularly. The child's heart recovered, but he remained unconscious. There was a stormy postoperative course. The temperature finally rose to 104°F. and the child died on February 27, 1955. The immediate cause of death was cerebral anoxia from prolonged apnea. Both eyes were enucleated at the time of autopsy.

MEASUREMENTS

	R.E. (mm.)	L.E. (mm.)
Anterior-posterior diameter	23	24
Horizontal diameter	23	24
Vertical diameter	23	24
Corneal horizontal diameter	13	13
Corneal vertical diameter	12	12.5

Right eye, 1095. Histologic measurements were made on a section that passes through the pupil and optic nerve. The lens measures 7.5 mm. by 1.7 mm. The trabecula from Schwalbe's line to the posterior tip of the scleral spur measures 0.8 mm. and to the angle 6.5 mm. The width of the trabecula was 0.07 mm. and there were approximately 14 layers of trabecular fibers between the anterior chamber and Schlemm's canal.

On histologic examination there is a scar of an iridectomy on one side. The cornea appears to be slightly thin. A loop of Descemet's membrane protrudes into the anterior chamber in the midportion of the cornea. On the side of the iridectomy there is also one area where Descemet's membrane is missing but endothelium has covered this region. There are slight anterior and posterior subcapsular cataractous changes and the lens capsule is thrown into folds in some areas. There has been some stretching of the cornea at the limbus so that the external surface of the corneoscleral junction is now about one mm. more central than Schwalbe's line. The deep scleral plexus of blood vessels appears to be normal.

The ciliary processes number three to four on either side. They are quite elongated on the unoperated side and are pulled centrally, running parallel to the posterior surface of the iris and touching it in many places. These fibers arise off the anterior tip of the ciliary body. The angle on the unoperated side shows a fetal type with failure of separation of the ciliary body from the posterior one third of the corneoscleral trabecular fibers. The angle itself is composed of trabecular fibers on the external surface and ciliary body on the internal surface. This forms a V and the root of the iris is pulled out almost to the level of Schwalbe's line. The scleral spur can be well seen and is flattened and pulled forward. Schlemm's canal is a narrow patent slit of normal length (fig. 16).

Enmeshed in the trabecular network all the way back to the tip of the scleral spur are a number of red blood cells. These extend to the inner edge of Schlemm's canal and one or two red cells can be seen in Schlemm's canal itself. The trabecular fibers do not appear sclerosed or thickened. On the operated side there has been a basal iridectomy. The anterior tip of the ciliary body is adherent to Schwalbe's line. The circular and longitudinal muscles come forward well in front of the scleral spur. The area of Schlemm's canal can be found but appears to be completely flattened. No red blood cells are enmeshed in the trabecular meshwork on this side where the angle is completely blocked by the anterior adhesions. The remainder of the eye, including the retina, choroid, and sclera appear normal except for slight posterior bowing of the cribriform plate of the optic nerve.

Impression. The angle of the anterior chamber was a fetal type causing an apparent posterior displacement of Schlemm's canal. The ciliary processes and the anterior tip of the ciliary body were pulled to the central portion of the globe. A blockage of the angle by the adhesion of the ciliary body to the posterior third of the trabecular fibers was certainly not a complete one, for a number of red blood cells could be seen particularly in the inferior portion of the angle enmeshed in the tra-

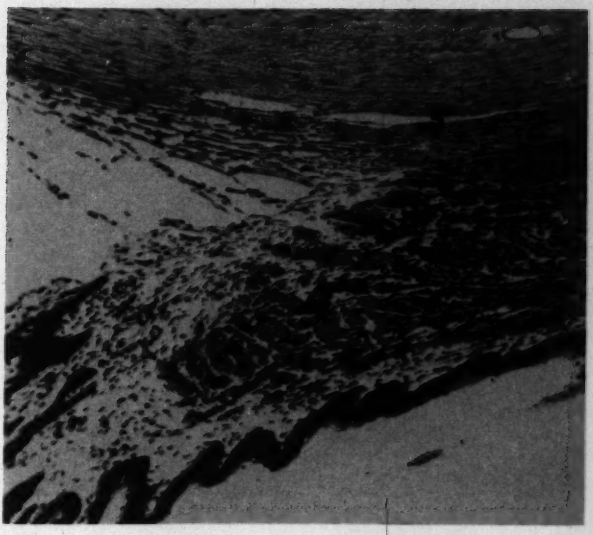

Fig. 16 (Maumenee). Case 6, R.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (4) Circular muscle. (×110.)

becular meshwork as far back as the scleral spur. In the area of the iridectomy above, where the ciliary body had become adherent to Schwalbe's line, no red blood cells could be seen. In other sections farther to the periphery beyond the area of the iridectomy, a few red blood cells can be seen in the trabecular meshwork.

Left eye, 1096. Examination of a section through the pupil and optic nerve showed that the lens measured 7.8 mm. by 1.7 mm. The trabecular fibers from Schwalbe's line to the posterior recess of Schlemm's canal measured 0.9 mm., and the angle from Schwalbe's line to the apex of the angle is 0.6 mm. The trabecular fibers are 0.07 mm. wide and number approximately 14 layers.

Histologic examination showed the external surface of the limbus was about one mm. farther centrally than Schwalbe's line. The cornea is slightly thinner than normal and there are several breaks in Descemet's membrane.

The ciliary processes and the anterior tip of the ciliary body are pulled way forward and centrally. The processes arise from the anterior tip of the ciliary body. The iris is somewhat thin but the stroma of the iris appears to be relatively normal except for thinning. The greater arterial circle of the iris is located more centrally than the anterior tip of Schlemm's canal. The deep scleral plexus of blood vessels appears to be normal.

Schlemm's canal is open and of normal length on both sides. The angle is of the fetal type. The ciliary body inserts to the posterior one third of the angle. The lens is oval in shape. The scleral spur is well developed but is pushed anteriorly and somewhat externally. The longitudinal muscle fibers and the oblique muscle fibers arise primarily from the trabecular fibers (fig. 17). They insert in front of the scleral spur.

Examination of the remainder of the eye shows the retina, choroid, and sclera to be normal except for some thinning of the sclera. There is marked posterior bowing of the cribriform plate of the optic nerve and some atrophy of the central bundle of nerve fibers.

Impression. A definite diagnosis of congenital glaucoma with atrophy of the optic nerve and marked posterior bowing of the cribriform plate was justified in this case. The angle was of the fetal type. The ciliary body and processes were drawn markedly to the central portion of the globe. There had been some stretching of the cornea just in front of Schwalbe's line. Schlemm's canal appears to be entirely patent.

B. Moderately advanced congenital glaucoma

Case 7.* C. G., age 19 months, white boy, history AFIP 142786. The child was born in December, 1943. One month after birth it was noted that he had congenital glaucoma. At four months of age on March 11, 1944, a trephination was done on the right eye. The trephine bleb became tremendous. This was cauterized on January 17, 1945. By July, 1945, the right eye increased to "one and a third normal size." The cornea measured 11 mm. in diameter in the horizontal plane. There was a marked ectasia extending from the 10- to 2-o'clock positions through the sclera in the area of the old trephination. The mass measured 8.0 mm. in diameter. The cornea was opaque. The tension was 40 mm. Hg in the right eye and 18 mm. Hg in the

* This case is reported with the kind permission of Captain Silliphant of the Armed Forces Institute of Pathology.

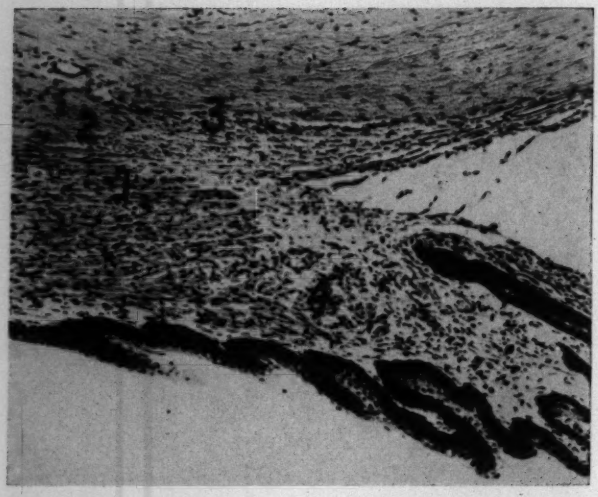

Fig. 17 (Maumenee). Case 6, L.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (4) Circular muscle. (×110.)

left eye. On July 12, 1945, the right eye was enucleated.

MEASUREMENTS

	R.E. (mm.)
Anterior-posterior diameter	26
Horizontal diameter	23
Vertical diameter	23

Histologic measurements. The lens measured 8.25 by 2.1 mm. The corneoscleral trabeculae from Schwalbe's line to the posterior tip of Schlemm's canal measured 0.75 mm. From Schwalbe's line to the apex of the angle is 0.23 mm. The width of the trabecular fibers is somewhat difficult to determine because of the solid adherence of the anterior part of the ciliary body to the trabecular fibers. However, I would estimate that the width is approximately 0.12 mm. and the fibers appeared to be increased in number to about 27 from the surface of the iris to the level of Schlemm's canal.

Histologic examination. The most obvious finding in this case is a large cystic bleb on the operated side. In spite of this the angle of the anterior chamber on the unoperated side is extremely interesting. The external surface of the corneoscleral junction to Schwalbe's line measures about 1.2 mm. Thus, there appears to have been some stretching on the unoperated side of the cornea also. The angle of the anterior chamber is almost completely obliterated by a persistence of the fetal angle. The longitudinal and circular muscles of the ciliary body come forward to only the tip of the scleral spur but the scleral spur is completely flat and very hard to find (fig. 18). The corneoscleral trabeculae appear to be reduced in number and the uveal trabeculae considerably increased in number.

Lying in front of the ciliary muscle there is some mesodermal tissue connected to the trabecular fibers for approximately 0.3 mm. The trabecular fibers that are exposed to the anterior chamber are thickened and have lost much of their endothelial covering. The iris stroma is markedly thinned and in most places the iris consists of only a thin layer of pigment epithelium. The circular muscle of the iris can be clearly seen. The cornea is quite thickened and vascularized. In spite of all these changes in the anterior part of the globe the cribriform plate shows only a slight amount of bowing and the ganglion cells are normal.

Impression. This was a more advanced stage of glaucoma in an eye that did not show much stretching because of the marked cystic bleb of the trephination. The angle of the anterior chamber showed the fetal type of development. One other interesting finding was the apparent increase in the number of corneoscleral trabecular fibers over that normally seen. Most of these were uveal tissue fibers.

CASE 8.* 54104—B = RE and A = LE. The patient was a colored girl whose mother had noted clouding of both corneas for a period of one month. The patient's brother had advanced congenital glaucoma. The patient's father had "big eyes but good vision."

Examination showed the corneal diameter to be 14 mm. in the right eye and 13.5 mm. in the left. The right cornea showed diffuse edema which clouded the media to the extent that the fundus could not be seen. In the left eye there was also slight corneal edema but less than in the right. The fundus could be seen with a −8.0D. sph. and appeared normal. On gonioscopic examination the angle of the right eye could not be visualized. In the left eye the angle appeared narrow despite the deep anterior chamber. Tension under general anesthesia measured right eye, 35 mm. Hg and left

* This case is reported with the kind permission of Dr. J. Wesley McKinney and Dr. T. E. Sanders.

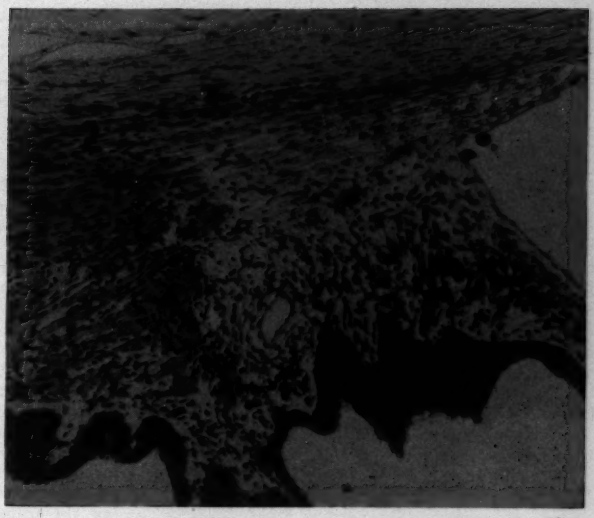

Fig. 18 (Maumenee). Case 7. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (4) Circular muscle. (×110).

eye, 17 mm. Hg. A goniotomy was done on the right eye from the 6- to 3-o'clock position. Two weeks later the tension in the right eye was 32 mm. Hg and a goniotomy was done from the 3- to 12-o'clock position.

The patient was not seen again until three and a half years later. At that time the tension under general anesthesia was right eye, 17 mm. Hg and left eye 27 mm. Hg. Gonioscopy showed the nasal angle of the right eye to be free except for a few anterior synechias. It was thought that goniotomy had cleared the angle. The angle in the left eye remained unchanged from previous examination and a goniotomy was done on the left eye from the 12 to 9 o'clock position. At the close of operation cardiac arrest occurred. The chest was opened and the heart massaged. The heart resumed its beating but the child remained unconscious and died 24 hours later.

Measurement of the histologic section of the right eye revealed the following: Anterior-posterior diameter 31 mm., transverse diameter 26 mm., and corneal diameter 16 mm.

Histologic examination showed the lens to be 9.5 by 1.6 mm. The trabecular fibers measured 0.75 mm. From Schwalbe's line to the apex of the angle of the anterior chamber measured 0.35 mm. The width of the trabecular fibers is difficult to determine because of the adherence of the ciliary body to them, but it appears about 0.12 mm. On the side of the goniotomy the trabecular fibers measure 0.07 mm. The fiber count on the unoperated side is extremely difficult because of the blending of the fibers but it appears that there are about 24 layers. On the operated side there are approximately 12 layers of fibers between Schlemm's canal and the anterior chamber. From the external surface of the limbus to Schwalbe's line is about 1.5 mm. (The limbus is greater than normal length.)

The ciliary processes are quite thin, originate at the anterior tip of the ciliary body, and are drawn toward the central portion of the globe. The vessels in the deep scleral plexus appear normal. On the unoperated side Schlemm's canal can be seen. It is definitely compressed but the endothelial cells do not appear adherent to one another. The scleral spur is pulled forward and blends in with the corneoscleral trabecular fibers to such a degree that it is difficult to see the tip of the scleral spur.

Both the longitudinal and oblique muscle fibers insert into the uveal portion of the corneoscleral fibers and these fibers appear to be somewhat in excess of normal. The muscle fibers extend farther forward than the tip of the scleral spur (fig. 19). In front of the muscle fibers there is an adherence of the ciliary body to the corneoscleral trabecula.

The trabecula in the anterior chamber appears to be somewhat thickened and sclerosed and there are fewer endothelial cells covering these fibers than normally. The iris stroma has a most peculiar appearance. It appears to be composed of pigmented cells with most of the stroma being washed out as frequently observed after an acute congestive attack of glaucoma with a very high tension. The sphincter muscle stands out very clearly and is not atrophic.

By far the most interesting part of this slide is the area of the goniotomy. The corneoscleral trabecula has been freed of the adhesion of the ciliary body. The longitudinal and oblique muscle fibers have been pushed posteriorly so that they now originate 0.1 mm. behind the termination of the trabecular fibers. The sclera has been incised in two places to the extent there appear to be two scleral spurs (fig. 20). The connective tissue scar extends about 0.2 mm. behind the original end of the corneoscleral trabecular fibers. Schlemm's canal can be seen on this side and is patent. The anterior

Fig 19 (Maumenee). Case 8, R.E. (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (×110.)

tip of the trabecular fibers appears to be somewhat thickened, but the posterior fibers appear to be of normal thickness.

The retina shows marked loss of the ganglion cell layer. There is advanced glaucomatous cupping and atrophy.

Impression. The angle of the anterior chamber on the unoperated side showed a typical fetal condition. On the operated side it appeared as if the goniotomy had separated the root of the iris and the ciliary body from the trabecular fibers and had caused a posterior displacement of the meridional and circular bundles of the ciliary muscle. Schlemm's canal remained patent on both sides. The ciliary processes did not look a great deal different from those of other eyes with advanced congenital glaucoma in which the tension has remained elevated. The goniotomy in this eye was apparently functioning and the lowered intraocular pressure was not due merely to hyposecretion, for the ciliary processes did not show excessive atrophy.

Left eye, 54104 A. Measurements of the globe from the histologic section are somewhat difficult because the eye had been distorted in fixative and in preparation. The globe, however, measures approximately 27 mm. in anterior-posterior diameter and 25 mm. in the transverse diameter. The cornea measures approximately 13 to 14 mm. in diameter.

The lens has been lost in sectioning. I do not have a section going through the center of the pupil but the trabecular fibers from Schwalbe's line to the posterior part of Schlemm's canal measure approximately 0.6 mm. From Schwalbe's line to the apex of the anterior chamber on the unoperated side measures 0.2 mm. The width of the trabecular fibers is difficult to estimate because of the distortion of the section. On a very rough estimation there appear to be approximately 15 layers of trabecular fibers.

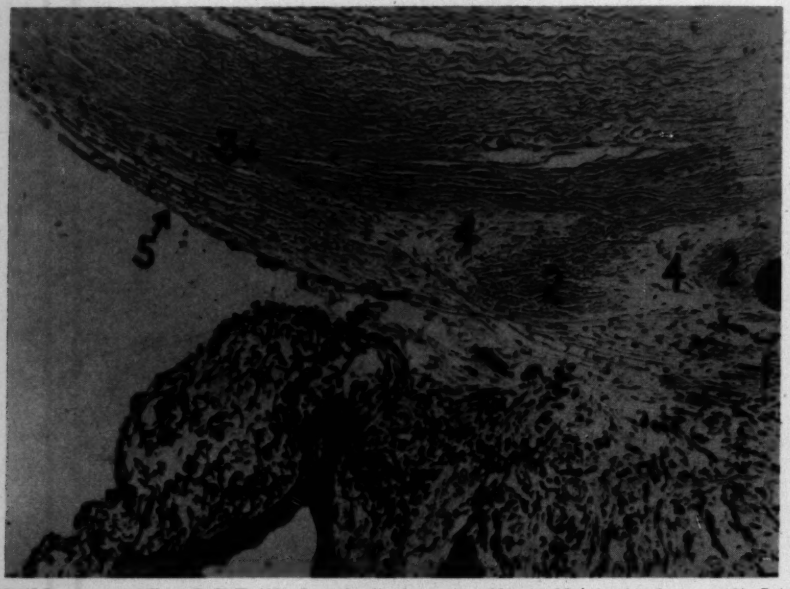

Fig. 20 (Maumenee). Case 8, R.E. (1) Longitudinal muscle. (2) Artificial scleral spur. (3) Schlemm's canal. (4) Operative scar. (5) Trabecula. (×110.) (Note ciliary muscle detached from trabecular fibers and reattached to scleral scar. Thus, ciliary muscle has no effective pull on trabecular fibers.)

The ciliary processes run approximately parallel to the posterior surface of the iris and appear about as they do in the other eye. The iris has the same appearance as in the right eye.

The angle of the anterior chamber on the unoperated side shows the failure of fetal separation of the ciliary body from the trabecular processes. There has been an artificial separation of the trabecular fibers in the angle on this side from technical difficulty. The longitudinal muscle bundle is detached with the corneoscleral trabecular fibers. Only two or three layers of corneoscleral fibers remain over Schlemm's canal. This gives a nice anatomic demonstration of how most of the meridional and oblique muscle fibers insert into the corneoscleral trabecula.

A number of red blood cells can be seen intermingled with the trabecular fibers as far posteriorly as the scleral spur. No red cells, however, are seen in Schlemm's canal (fig. 21).

On the opposite side there has been a recent goniotomy. In most sections the ciliary body has been cleaved from the corneoscleral trabecular fibers. The circular and meridional muscle bundles have been pushed posteriorly. There are a few red blood cells that permeate the remaining trabecular fibers over Schlemm's canal. In many sections Schlemm's canal is quite wide open due to the relaxation that has been caused by the goniotomy in releasing the adhesions of the ciliary body and muscle fibers to the overlying trabecular fibers. The remaining trabecular fibers which extend from the scleral spur forward over Schlemm's canal measure 0.07 mm. thick and there are approximately 10 layers of fibers remaining (fig. 22).

Fig. 21 (Maumenee). Case 8, L.E. (1) Trabecula with red blood cell enmeshed. (2) Schlemm's canal. (3) Cornea. (×725.)

Examination of the remaining parts of the eye shows that the retina is in good condition. There are a large number of ganglion cells in the retina in the macular region. There is very little posterior bowing of the cribriform plate and the optic nerve shows practically no atrophy.

Fig. 22 (Maumenee). Case 8, L.E. Site of goniotomy. (Note detachments of longitudinal muscle.) (1) Goniotomy incision. (2) Schlemm's canal. (3) Trabecula. (×110.)

Impression. There was a fetal condition of the angle on the unoperated side and a recent goniotomy on the other. The ability of red blood cells to permeate the corneoscleral trabeculae on the unoperated side indicated that the fetal condition of the angle could not completely prevent filtration on this side.

C. Eyes with advanced congenital glaucoma

Sixty eyes with advanced congenital glaucoma have been studied histologically. These eyes have been removed because they were blind, disfiguring, and frequently painful. The age of the patient at the time of enucleation varied from two to 45 years.

In 35 of the eyes, the iris was adherent to the back of the cornea or the globe had been so disfigured from operative procedures that little remained for study of the angle of the anterior chamber. In the other 25 eyes, however, the structures in the anterior chamber could be recognized fairly clearly. The lesions that were present in the anterior segment of the globe were as follows: The iris and the anterior tip of the ciliary body were inserted into the trabecula, usually in the posterior third. The scleral spur was extremely flattened and the longitudinal and oblique muscle fibers appeared to be attached predominantly to the trabecular fibers rather than to the scleral spur.

In seven eyes that measured up to 35 mm. in length, with corneal diameters up to 17 mm., Schlemm's canal could still be seen. In other eyes the walls of the canal were tightly compressed to one another and it was impossible to tell whether it was actually patent or not. In many instances, the specific area of the canal could not be recognized. In eyes with more advanced glaucomatous change, the trabecular fibers, particulary those exposed to the anterior chamber, appeared to become thicker and lose their endothelial covering. The fibers covered by the uveal adhesion became more compact and were difficult to identify one from the other. In several instances the number of fibers appeared to be greater than normal, increasing to approximately 27 in number.

Very interestingly, the trabecular fibers did not increase in length as the globe enlarged. Even in the most distended globes the trabecula length remained at approximately 0.75 to 0.9 mm., as measured from Schwalbe's line to the posterior recess of Schlemm's canal. The greatest area of stretching occurred from Schwalbe's line anteriorly at the limbus, so that in very distended globes from the external part of the limbus to Schwalbe's line measured as much as 5.0 mm. (fig. 23). The angle of the anterior chamber became more obtuse and in some instances reached almost 90 degrees. The iris stroma became quite atrophic and tended to disappear so that at times only a few blood vessels, the muscle fibers of the constrictor and dilated muscle, and the epithelial pigment layer of the iris remained. In some instances a glassy membrane extended from the back of the cornea over the anterior surface of the iris.

Summary of pathologic changes. The most obvious finding on histologic examination of eyes with early congenital glaucoma, both in cases previously reported and those described here, are: An apparent failure of separation of the iris and ciliary body from the trabecular fibers. The extent to which this occurs is extremely variable. In one case almost the full extent of the trabecular fibers will be covered and in another the ciliary body may be adherent to only the most posterior end of the trabecula. In the few cases available for study, the extent of these adhesions is roughly inversely proportional to the age of the patients at the time of the onset of the disease. Thus in those patients who have a steamy cornea at birth the adhesions are more extensive than in those eyes in which the disease begins three to six months after birth.

A second finding that occurs with equal consistency in an abnormally extensive insertion of the longitudinal and circular muscle fibers into the trabecula. In many in-

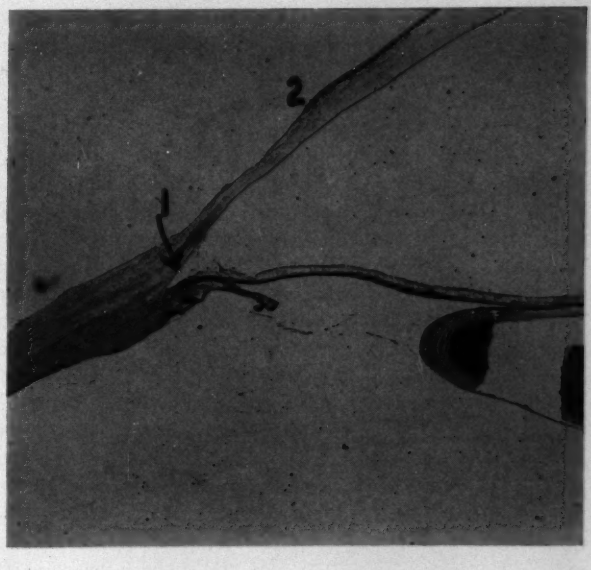

Fig. 23 (Maumenee). Advanced congenital glaucoma showing limbal stretching. Trabecula normal length. (1) Schwalbe's line. (2) External limbus. (×10.)

stances these fibers extend forward beyond the anterior tip of the scleral spur and posterior one fourth of Schlemm's canal. The tip of the scleral spur is difficult to see because of its displacement forward and externally.

The ciliary body is frequently pulled centrally so that the bases of the ciliary processes are central to a line that passes vertically through the posterior end of Schlemm's canal.

The trabecular meshwork is permeable to red blood cells even when there are extensive adhesions of the iris and ciliary body to the trabecular fibers. Schlemm's canal can be found in all cases of early congenital glaucoma but is usually collapsed. This is probably related to the *anterior external position of the scleral spur.*

In eyes with advanced congenital glaucoma the same failure of separation of the iris and ciliary body from the trabecular fibers is found in many eyes. Sclerosis and thickening of the trabecula and a relative loss of endothelial cells on these fibers results from a long-standing elevated intraocular pressure. The trabecular zone does not increase in length but the region from Schwalbe's line to the external limbus stretches markedly.

The iris shows progressive atrophy of the stromal tissue. In some eyes inflammatory cells are present in the iris and ciliary body. These appear to be secondary to the glaucoma.

Gonioscopy

Gonioscopic examination has been done on approximately 25 normal infants under the age of two years and 50 patients with congenital glaucoma. The angle of the anterior chamber in infants differs from that in the adult in several ways. First, the trabecular fibers appear more translucent than they do in the adult so that one has the feeling of being able to see deeper into the tissue or that a possible membrane overlies the trabecular fibers. In addition, iris processes are much more frequent than they are in the adult. These in blond infants appear as nonpigmented fiber bands extending from the surface of the iris to Schwalbe's line. In Negroes, they are heavily pigmented. Frequently the ciliary sulcus is not as evident

in children as it is in the adult. The anterior tip of the ciliary body, however, can be seen.

The angle of the anterior chamber in congenital glaucoma in many instances is quite similar to that seen in the normal infant. In other instances, probably in five to 10 percent of the cases of congenital glaucoma, the iris appears to insert quite forward on the trabecular fibers. In other instances, the defect is a much more subtle one and it appears that the trabeculae are of normal length. This is in keeping with the histologic finding, for when one observes the angle of the anterior chamber through the gonioscope the line of vision usually passes close to the apex of the cornea and thus the trabecular fibers are not viewed as a flat plane perpendicular to the line of vision but one looks at them rather tangentially. Thus, if the exposed length of the trabecular fibers is reduced from 0.75 mm. in length to 0.35 to 0.45 mm. and if the material covering the trabecular fibers is relatively nonpigmented (as the base of the iris or ciliary muscle would be in a blond infant) the angle would probably appear as entirely normal. Also, when blood entered Schlemm's canal, it would be projected through the middle third of the trabecular fibers because of the angle at which these fibers are viewed. Schlemm's canal would, therefore, appear to be anterior to the attachment of the iris and ciliary body.

No cellophanelike membrane or jellylike material which might be interpreted as a persistent mesodermal mesh was observed in the angle of the anterior chamber. The surface of the iris, however, was frequently covered by a filmlike structure that probably represented atrophy of the iris tissue. The iris blood vessels in slightly advanced cases are quite prominent and vessels in the cilary body and base of the iris may appear to be attached to the trabecular wall.

Blood can usually be forced into Schlemm's canal by tilting the patient's head downward or by compressing a contact lens on the globe or if necessary by compressing the jugular vein. This is particularly true when the intraocular pressure is normal. If the tension is elevated and blood cannot be forced into Schlemm's canal, then removal of a small amount of aqueous will allow this to occur.

After a successful goniotomy, the iris and ciliary body frequently appear to be recessed (fig. 24). In some instances where the angle has appeared almost normal prior to operation this recession may be extremely slight. In other instances, the iris may appear to adhere even farther forward on the trabecula following operation than it did before and still the operative procedure might function.

Discussion

It is always dangerous to draw conclusions in regard to physiologic functions from morphologic observations alone. However, this is part of the pleasure of histopathology. If one clearly separates the observations from the theory evolved, the results should not be too disastrous. Thus in the foregoing section the findings have been listed and illustrated. In the following section an attempt will be made to explain the cause of the raised intraocular pressure in congenital glaucoma.

First, what are the positive findings in congenital glaucoma? They are:

1. A lowered facility of aqueous outflow as shown by tonography.

2. An increased facility of aqueous outflow following a successful goniotomy.

3. A patent Schlemm's canal in early cases (as demonstrated by the ability to force blood into the canal when the pressure is normalized) and the presence of the canal in histologic sections, even though it may be collapsed.

4. The absence of an unabsorbed mesodermal mass which blocks the trabecula.

5. An incomplete cleavage of the root of the iris and ciliary body from the trabecula. Along with this the longitudinal and circular muscle fibers insert farther forward and to a greater extent than normally into the trabecular fibers. The scleral spur and Schlemm's canal are compressed externally.

6. The adhesions of the iris and ciliary body do not block the filtration of the tra-

Fig. 24 (Maumenee). Postoperative gonioscopic view of goniotomy for congenital glaucoma. (Note recession of iris and ciliary body.) (1) Anterior insertion of iris. (2) Anterior synechia. (3) Goniotomy scar.

becular meshwork in early cases of congenital glaucoma for when hemorrhage occurs in the anterior chamber, red blood cells readily pass through the mesh to the inner wall of Schlemm's canal.

7. A successful goniotomy cleaves the root of the iris and ciliary body from the trabecular fibers. This causes a posterior displacement of the circular and longitudinal muscle fibers and leaves the trabecular fibers exposed to the anterior chamber. It also leaves Schlemm's canal intact.

How do the above findings support or discredit the theories which have been previously used to explain congenital glaucoma?

First, the results of tonography before and after a successful goniotomy place the lesion in the filtration angle. Since goniotomy may be successful after a very superficial incision this would indicate that the deep scleral plexus of blood vessels is probably not involved.

Second, the lesion is not due to an absence of Schlemm's canal nor to a defect in the outlets from the canal, for blood can be forced into this area in most instances, demonstrating its patency.

Third, no mesodermal mesh or cellophane membrane covers the trabecular fibers.

Fourth, adhesions of the ciliary body to the trabecular fibers may contribute to glaucoma by acting as a partial block. This may be especially true in those cases which occur at birth, such as Seefelder's Case 2 and the first case in this report. However, as pointed out by Shaffer,[4] the extent of these adhesions varies greatly in many cases and in some it does not seem sufficient to account for the blocking of the aqueous from Schlemm's canal. More positive evidence against this mechanism in some cases is the fact that despite such adhesions red blood cells have been found to pass freely from the anterior chamber through the trabecular fibers to the outer wall of Schlemm's canal (Cases 2, 5, 6, and 8). If red blood cells have free passage through this area, then there is little reason to think that aqueous would be blocked by such a mechanism. Likewise, a similar reasoning would apply to a cellophane membrane which might be seen gonioscopically and be destroyed in the histologic preparation of a specimen.

Finally, the trabecular fibers and the wall

of Schlemm's canal appear to be capable of normal filtration, for examination of an eye in which the tension had been controlled for three and a half years by successful goniotomy showed that these structures were still intact but that the ciliary muscle and iris had been detached from the trabecular fibers (case 8).

These findings appear to negate all of the theories that have been used in recent years to explain the elevation of intraocular pressure in congenital glaucoma. Is there an alternative explanation which might fit the histologic and clinical findings?

There are two approaches to this question:

The first is to attribute the elevated pressure to some unknown neurovascular or humoral basis. For such a theory there is little evidence at the present time but it does offer an interesting field for speculation.

The second approach is to look for some mechanical factor which may retard filtration. If such is found one must then look further to discover the pathogenesis of this mechanical factor. For the moment only the possibility of a mechanical factor will be discussed. Such an impediment may be the insertion of the longitudinal and circular ciliary muscle fibers into the trabecular fibers anterior to the scleral spur. In order to explain how this might block the outflow of aqueous it is necessary to review the changes which normally take place when the ciliary muscle contracts and relaxes.

Thomson, in 1911,[38] showed that the longitudinal fibers of the ciliary muscle inserted primarily into the scleral spur. When these fibers were pulled upon, and the specimen observed under magnification, the spur was displaced posteriorly and Schlemm's canal opened. Fortin[39] demonstrated a similar movement of the spur in an eserinized eye which was rapidly fixed after enucleation.

Recently, Ashton and his co-workers[40] have restudied the structure of the trabecular fibers and have noted that the long axes of the trabecular fibers run in a circular manner parallel to Schwalbe's line. There are oval openings in the meshwork whose long axes lie in the same direction. These openings are so arranged that one layer of trabecular fibers tends to cover the opening in the adjacent layer.

Heine,[41] in 1899, demonstrated by means of histologic preparations that atropine produced a flattening and eserine a contraction of the ciliary muscle in monkey eyes. When contraction occurred the circular muscle moved centrally and forward as if it were rotated through a circle with the innermost trabecular fibers acting as the radius. The longitudinal fibers also contract, adding thickness to the ciliary body and retracting the scleral spur. Flocks and Zweng[42] have repeated and extended these studies to show that such changes produce a spreading of the trabecular fibers (figs. 25 and 26). In addition, by means of flat preparations of the trabecula, they demonstrated that the pores change their shape from oval to round openings, thus increasing the filtration area.

If in the light of these findings one reviews the histologic sections of the angle in congenital glaucoma, it will be noted that the circular muscle of the ciliary body is frequently held forward by an attachment to the trabecular fibers, and the oblique and longitudinal muscle fibers appear to be attached to a greater extent than normal to the trabecular fibers. In many instances, these latter two groups of muscle bundles also appear to extend in front of the anterior tip of the scleral spur. With this arrangement the longitudinal fibers tend to compress the scleral spur externally and thus narrow Schlemm's canal. If they contract, the canal is narrowed further rather than opened as normally occurs. The circular muscle being attached to the inner surface of the trabecular fibers, instead of the ends of the fibers, would not exert the normal spreading effect to open the trabecular spaces.

Ordinarily the scleral spur or roll is the innermost projection of the anterior tip of the sclera. In histologic slides minute variations in this area are frequently artefacts.

Fig. 25 (Maumenee). Monkey eye under atropine. (Note flattening of ciliary body.) (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (4) Circular muscle. (×80, from Flocks.)

However, in some eyes with early congenital glaucoma the internal apex of the corneoscleral junction appears to lie just anterior to the scleral roll. In such instances the pull of the longitudinal muscle on the trabecular fibers would have an even greater tendency to narrow or close the canal.

The clinical course of congenital glaucoma and the late pathologic finding are compatible with this theoretic mechanism for producing an elevated intraocular pressure. First, congenital glaucoma is frequently a cyclical disease during its early stages. Thus, on one day a child will have a cloudy cornea, epiphora, and photophobia and on the next day appear normal. The tension may be normal on several occasions under general anesthesia and several weeks later under similar conditions will be found to be elevated. Pashby and Halliday[6] have noted in children with con-

Fig. 26 (Maumenee). Monkey eye with pilocarpine. (Note contraction of ciliary muscle and retraction of longitudinal muscle and scleral spur. Opening of trabecular fibers.) (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (4) Circular muscle. (×80, from Flocks.)

genital glaucoma that there is a marked reduction in the intraocular pressure when the child goes to sleep. If the pressure were elevated because of a blocked angle from an adhesion, the elevation would be more constant. Pilocarpine is usually ineffective in controlling the elevated tension over long periods of time.[1] Recently Nonnenmacher[43] reported two complicated cases of congenital glaucoma that did not respond to pilocarpine but did to atropine.

Histologic examination of early cases shows that the scleral spur tends to lie more parallel to the scleral fibers than is usually found in eyes of normal children of the same age. In more advanced cases of congenital glaucoma, the spur becomes still further collapsed as if it were being compressed outward by the meridional muscle fibers.

The histologic appearance of an eye after a successful goniotomy is also an argument for the idea that an abnormal pull of the ciliary muscle is in some way connected with this type of glaucoma. One of the principal effects of the operation is to dissect the longitudinal ciliary muscle from its attachment to trabecular fibers, leaving the trabecula free of muscle attachments.

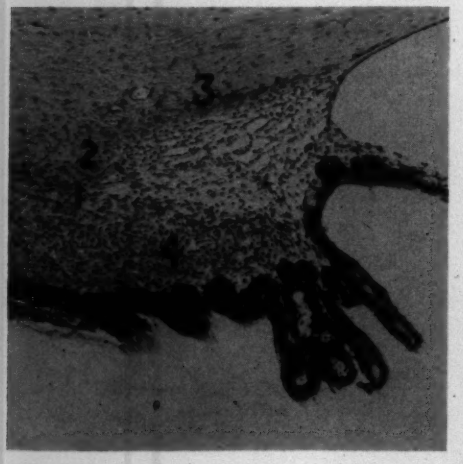

Fig. 27 (Maumenee). Persistent hyperplastic vitreous. (Note looseness of uveal trabecular fibers and condensation of corneoscleral trabecular fibers.) (1) Longitudinal muscle. (2) Scleral spur. (3) Schlemm's canal. (4) Circular muscle. (×110.)

Barkan[25] has observed that, after a successful goniotomy, when he fills Schlemm's canal with blood, a normal red band appears in the operated area where Schlemm's canal should be. This would not occur if the trabecular fibers and the canal had been incised by goniotomy.

There is other evidence that the fetal condition of the angle of the anterior chamber and an abnormal insertion of the ciliary muscle are concerned in the pathogenesis of congenital glaucoma. In seven of eight eyes with persistent hyperplastic vitreous the angle of the anterior chamber showed changes similar to those seen in eyes with early primary congenital glaucoma (fig. 27). Two of these eyes had developed glaucoma. In the remaining five eyes glaucoma had not developed at the time of enucleation, but all of these patients were less than three months of age. It is known that congenital glaucoma is a frequent complication in eyes with persistent hyperplastic vitreous.

Further evidence for or against this suggested mechanism for producing an elevated pressure in congenital glaucoma may be obtained by repeated recordings of the ocular tension and tonographic tracings. These recordings should be done on the same eyes before medication is used, after intensive miotic therapy and after complete atropinization.

A possible clue to the pathogenesis of the anterior insertion of the ciliary muscle into the trabecular fibers is found in the occurrence of this abnormality in eyes with persistent hyperplastic vitreous. In these latter cases, it would appear that the abnormal central pull on the ciliary processes and ciliary body, before cleavage of the angle occurred, prevents the normal migration of the muscle backward. A similar forward displacement of the muscle and adhesions to the trabecula did not occur in 38 eyes with retrolental fibroplasia and other conditions which caused postnatal leukocoria.

Mann[18] mentions that congenital glaucoma

may occur in eyes with microphakia and ectopia lentis. I have not examined such eyes histologically. The possibility that a slightly smaller lens than normal may exert an abnormal pull on the ciliary body during fetal development and thus play a part in the pathogenesis of this disease is an intriguing thought. The size of the lens in congenital glaucoma has been variedly estimated as smaller, normal, and larger than normal. These figures are hard to evaluate, for it is not always clear whether the measurements were made on histologic sections or on gross specimens. Likewise, it is not known what effects increased intraocular pressure or an abnormal pull of the zonular fibers will have on the growth of the lens. Nevertheless, there is little question that a lens is relatively microphakic once an eye begins to enlarge from congenital glaucoma. The subsequent pull of the zonular fibers certainly adds to the central displacement of the ciliary body.

Summary

1. The tonographic, histologic, and gonioscopic findings in cases of early congenital glaucoma indicate that in the majority of cases the elevated intraocular pressure is not caused by: (1) an absence of Schlemm's canal, (2) an unabsorbed mesodermal tissue or membrane over the trabeculae, (3) a block of the filtration angle by adhesions of the iris to the trabecular fibers, although there are a few cases in which this may be a factor, or (4) a defect in the collector channels, deep scleral plexus of blood vessels, or vortex veins.

2. It is suggested that the raised intraocular pressure is due to an abnormal insertion of the longitudinal and circular bundles of the ciliary muscle into the trabecular fibers. This defective insertion tends to compress the scleral spur forward and externally, thus narrowing Schlemm's canal. Contraction of the longitudinal muscle fibers further narrows the canal rather than opening it. Contraction of the circular muscle fibers does not open the trabecular spaces.

3. The above conclusions are based on the following observations:

a. Tonographic tracings show a low facility of outflow in congenital glaucoma.

b. Pilocarpine does not control the elevated tension.

c. Successful goniotomy increases the facility of aqueous outflow.

d. Gonioscopy usually reveals an open angle. Occasionally there is an anterior insertion of the iris. No abnormal mesodermal membrane is seen over the trabecular fibers.

e. Blood can be forced into Schlemm's canal when the tension is normal or low in early cases of congenital glaucoma.

f. Schlemm's canal can be seen on histologic section in early cases of congenital glaucoma.

g. Red blood cells filter through the trabecular fibers from the anterior chamber to the outer wall of Schlemm's canal.

h. Histologic examination of eyes with early congenital glaucoma shows the longitudinal and circular fibers of the ciliary muscle inserted into the trabecular fibers in front of the scleral spur. In eyes with advanced congenital glaucoma the scleral spur is compressed forward and external to such an extent that it is difficult to find.

i. In four eyes histologic examination showed the longitudinal and circular muscle fibers of the ciliary body were dissected, by goniotomy, from the trabecular fibers. In three instances the patient died shortly after operation. In one eye the glaucoma was controlled and the patient lived three and a half years after operation.

j. In eyes after a successful goniotomy blood can be seen in Schlemm's canal, on gonioscopic examination, in the area of operation. Histologically the outer layers of trabecular fibers and Schlemm's canal are not destroyed.

k. The goniotomy incision does not produce a cleft over the ciliary body as is done in cyclodialysis nor does it penetrate deeply enough into the sclera to affect the deep scleral plexus of blood vessels.

4. The length of the trabecular fibers does not increase as the eye enlarges in congenital glaucoma. The stretching occurs in the cornea so that the external limbus instead of being located just over Schwalbe's line may be five millimeters anterior to it.

The Johns Hopkins Hospital (5).

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LYMPHOSARCOMA OF LACRIMAL AND SALIVARY GLANDS*

RALPH S. HAMILTON, M.D., AND IRVING H. LEOPOLD, M.D.
Philadelphia, Pennsylvania

Lacrimal gland enlargements may have a variety of etiologies. An infrequent cause of such a finding is lymphosarcoma, as demonstrated in the following case.

CASE REPORT

C. S., a 70-year-old white woman, was admitted to Wills Eye Hospital on July 12, 1957, with a chief complaint of swellings in both upper lids and of a swelling at the angle of the right mandible. Her present illness dated back to one year previously, at which time she first noted a small mass in the left upper eyelid. This gradually became larger and she consulted an ophthalmologist in her home town. X-ray studies of the orbit were negative and the tumor was excised. Pathologic studies failed to establish a diagnosis.

Soon after this she developed a swelling in the right upper eyelid and, three weeks prior to her admission to the Wills Eye Hospital, she developed a swelling at the angle of the right mandible. She had been followed by her ophthalmologist for eight months prior to her referral to Wills Eye Hospital for further studies and treatment. Her past medical history appeared unrelated to her present complaints although it included a ruptured appendix in 1914, herpes zoster, acute hepatitis due to infection, and hypoproteinemia in 1951. In 1951 she had been hospitalized and had a thorough work-up of her gastrointestinal and cardiovascular systems which failed to reveal any malignancy.

General physical examination showed an elderly female, well-developed and somewhat obese. Blood pressure was 150/66 mm. Hg; pulse 64. Examination of head and neck was significant and will be described in more detail with the eye examination. Lung fields were clear. Cardiac studies revealed PMI in fifth intercostal space in left midclavicular line with a Grade 1 aortic systolic murmur. The abdomen revealed no palpable mass. Liver and spleen were not enlarged. There were no palpable lymph nodes in axilla, supraclavicular, or inguinal regions. Breasts showed no masses. Extremities had no palpable or visible edema.

Eye examination. Visual acuity was: O.D., 6/30 and 6/15, with correction; O.S., 6/60 and 6/21 with correction. Intraocular pressure was: O.D., 20 mm. Hg; O.S., 20 mm. Hg (Schiøtz).

External examination. There was no enophthalmos or exophthalmos. Lids revealed large tumor masses 3.0 by 2.0 cm. in the right upper lid over the lacrimal gland area and 2.5 by 1.75 cm. in the left upper lid over the lacrimal gland area. These masses were firm, nonmovable, not fixed to skin, and were painless. The tumor masses were so large that the patient had almost complete ptosis of both lids. In addition to the tumor masses was a large, firm, disc-shaped mass 4.0 by 5.0 cm. in the right periauricular and parotid region. This mass was firm, nonmovable, nontender, and not fixed to skin. Also there was a large submaxillary gland on either side measuring 2.0 by 3.0 cm. Cilia and the lacrimal drainage apparatus were normal. The conjunctiva showed some chemosis. The corneas were normal. Anterior chambers were of normal depth. Irises were normal. Pupils were round, regular, and equal, and responded to light directly and consensually.

Muscle balance revealed marked limitation of lateral rotations in each eye, neither eye being able to rotate to the midline from its more or less fixed nasal displacement. The patient was unable to look up and out at all; rotations up nasally and down nasally were not restricted. She had 15 degrees of esotropia and complained of diplopia when both lids were manually elevated. She had a complete ptosis on the right and almost complete ptosis on the left.

Fundus examination revealed the media to be clear, disc of good color, margins were distinct, cupping was physiologic, vessels revealed normal light reflex, there were no hemorrhages or exudates, macular reflexes were good, and there were no stress signs in the fundi.

Impressions at this time were: (1) Bilateral lacrimal gland tumors with extensive preauricular lymphadenopathy on right or parotid gland swelling on right, and bilateral submaxillary adenopathy. It was felt that this could be considered a Mikulicz's syndrome, probably based on sarcoidosis or some nonspecific granuloma. (2) The second consideration was that this could be a primary or metastatic malignancy of lacrimal glands.

* From the Wills Eye Hospital.

Laboratory studies. Complete blood count revealed hemoglobin of 12.5 gm. or 81 percent; red blood count 4,810,000; white blood count 4,950; differential count was segmented, neutrophils 62 percent, lymphocytes 32 percent, monocytes one percent, eosinophiles two percent, and bands three percent. Urinalysis. Albumin: negative; sugar: negative; specific gravity: 1.022; acid reaction: microscopic examination revealed two or three white blood cells, a rare red blood cell, and loaded with mucous. Blood sugar was 90 mg.; sedimentation rate, 8.0 mm. in 60 min.; Lee and White coagulation time: 10 min., 30 sec., bleeding time two min., 15 sec. Total serum protein: 5.1, albumin 3.5, globulin 1.6; test for Bence Jones protein, in urine negative.

X-ray studies revealed calcification of internal carotid arteries, otherwise normal skull, orbits, paranasal sinuses, and optic foramina. The chest X-ray film showed an arteriosclerotic aorta and left ventricular enlargement. There was no widening of hilar or mediastinal nodes. X-ray films of hands and feet showed osteoparetic changes but nothing to suggest sarcoidosis.

On July 16, 1957, on the tentative diagnosis of nonspecific granuloma, the patient was started on 20 mg. of ACTH in 500 cc. of five-percent glucose in distilled water for three days and Chloromycetin, 500 mg. every six hours.

On July 20, 1957, she was put on ACTH, 40 mg. in the form of Acthar Gel intramuscularly twice a day and potassium chloride 1.0 gm. daily. She was also started on 50 mg. of prednisolone twice a day.

Two days after instigation of ACTH therapy all of the masses began to resolve. Within four days there was complete resolution of both submaxillary glands and of the large mass in the right parotid region. The masses over both lacrimal glands were diminishing in size. After one week of steroid therapy, the patient could open both lids to the level of uncovering one half of each pupil.

A biopsy was taken to establish the diagnosis. This was done on July 23, 1957, uneventfully under local anesthesia from the site of right lacrimal gland.

This patient was discharged from the hospital on August 2, 1957, on 5.0 mg. of prednisolone four times a day and 1.0 gm. of potassium chloride daily. At the time of her discharge the masses over each lacrimal gland area were approximately one third their original size. The patient no longer had diplopia except on lateral gaze, indicating a resolution of the orbital extension of these masses. The ptosis was disappearing and the patient subjectively felt well.

Readmission. The patient developed a fever on August 12, 1957, and sores in her mouth. She was started on mycostatin at home at this time since it seemed that she might have developed moniliasis or one of the fungus infections with the steroid treatment. She did not improve and was readmitted on August 15, 1957. At this time she complained of fever and malaise. General physical examination revealed a temperature of 102°F. orally, rales in the right lower lung fields, and percussion dullness over this area. X-ray studies of the chest now revealed a confluent bronchopneumonia at the base of the right lung. Routine red blood count, differential, and urinalysis were all normal. First and second strength Mantoux tests were again negative.

Treatment consisted of prednisolone, 10 mg., three times a day, Mysteclin, 250 mg., four times a day, and Mycostatin, two tablets (1,000,000 units), four times a day.

Microscopic studies of the biopsy specimen established the diagnosis of lymphosarcoma. In view of this microscopic diagnosis, the patient was given 6.0 mg. of nitrogen mustard intravenously daily for four days, starting on August 21st. On August 20, 1957, Mysteclin and Mycostatin were discontinued. By August 26th, X-ray studies of the chest revealed almost complete resolution of pneumonia and the patient was discharged home on August 27, 1957, on prednisolone, 5.0 mg. three times daily for one week, then twice a day and KCl, 1.0 gm., three times daily. The lacrimal masses were almost completely resolved in both eyes. The right eyelid was in normal position, the left was still slightly ptotic.

On December 14, 1957, the patient revealed no signs of any enlargement of lacrimal glands, parotid, or cervical lymph nodes. She did have a slight ptosis of left upper lid, but no ptosis of right upper lid. She was in good spirits and apparently in good health. On July 28, 1958, the patient's family reported her to be in good health with no evidence of recurrence of the tumor masses in either lid, preauricular, or cervical regions.

Discussion

Lacrimal tumors have been said to compose four to 15 percent of all orbital tumors by Forrest.[2] Duke-Elder[1] states that five percent of tumors of the lacrimal gland are derived from lymphoid tissue. Forrest[2] has given us a rather complete pathologic classification of all lacrimal gland tumors. He considers four main groups as follows:

A. Epitheloid lacrimal gland tumors
   1. Benign or mixed tumors of lacrimal gland.
   2. Malignant lacrimal gland tumors
      a. Adenoid cystic type
      b. Adenocarcinoma
      c. Squamous cell carcinoma
      d. Undifferentiated carcinoma
      e. Malignant mixed tumors

B. Inflammatory disease
   1. Sarcoid
   2. Nonspecific granulomas

C. Localized evidence of a lymphoma (into which class this case may be classified.)

D. Neoplasms or inflammation unrelated to the lacrimal gland as metastatic lesions

The treatment of the above lacrimal gland involvments may be summarized as follows:

Group A responds only to complete and adequate removal of all the tumor and structures, including the bony lacrimal fossa, which are invaded by the tumor. Forrest[2] believes that the adenoid cystic type of carcinoma under the malignant lacrimal gland tumors is radiosensitive.

Group B usually responds best to systemic ACTH and steroid treatment. It is into this group that our patient was originally believed to belong. This was the rationale for the treatment with ACTH (adrenocorticotropic hormone). Attention is again called to the dramatic resolution of the tumors on this treatment.

Group C is best treated with radiation therapy. Biopsy must be done for diagnostic purposes.

Group D responds best to treatment directed at the primary site of the lesion.

There has been considerable overlapping and confusion as regards the classification of the lypmphomas involving the lacrimal glands. Duke-Elder[2] classifies them as follows: (1) Lymphoma, (2) leukemia, (3) lymphosarcoma, (4) reticulum-cell sarcoma, (5) giant follicular lymphoblastoma, (6) Hodgkin's disease.

It is well known that ocular manifestations of a lymphomatous disorder may be manifesting signs of a generalized spread of the disease or a prelude to development of a systemic lymphomatous disorder. These cases certainly must be very carefully followed over many years. McGavic[5] has stated that the lymphomatoid diseases are an ever-changing process that require repeated and careful biopsy and blood studies.

Survival rates of the lymphomatous disorders have been pointed out by Sugarbaker and Craver[8] to be influenced by: (1) inherent qualities for growth and dissemination; (2) extent of dosage when first treated; (3) localization of primary lesion, that is, outcome is much more favorable when primary site is in the head. Perhaps this is because tumors in this region present themselves to the patients early and these patients seek medical attention promptly. (4) Complicating leukemia increases mortality. (5) Age of onset, that is, the younger the patient the shorter the survival rate, the older the patient, the longer the survival rate.

Summary

In summary, a case of lymphosarcoma presenting itself as massive bilateral lacrimal and salivary gland swellings has been described. The dramatic resolution of the masses has been pointed out. While this patient did receive nitrogen mustard later in the course of her illness, the masses had all resolved and it is felt that the steroids and adrenocortinotropic hormones were responsible for this. A classification of lacrimal gland tumors has been presented and treatment has been described.

1601 Spring Garden Street (30).

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NOTES, CASES, INSTRUMENTS

RETINAL ISCHEMIA WITH CATARACT FORMATION

A CASE REPORT

F. H. NEWTON, M.D.
Dallas, Texas
J. H. ARRINGTON, M.D.
Wichita Falls, Texas
AND
R. GRADY BRUCE, M.D.
Dallas, Texas

An unmarried white woman, aged 69 years, was first seen by one of us (J. H. A.) in March, 1957, with a history of diaphragmatic hernia in 1951, thyroidectomy in 1954, acute respiratory virus infection and associated pleurisy in October, 1956, with a relapse or second attack in November, 1956, lasting three weeks. In November, 1956, the vision suddenly became affected. The patient was able to drive her car and read without difficulty one day; the next day vision markedly diminished in each eye. A competent ophthalmologist saw her at this time and made a diagnosis of bilateral heavy vitreous opacities with beginning cataract formation. Visual acuity reported was: R.E., 20/400; L.E., 20/100.

The first recorded blood examination was made at Bethania Hospital, Wichita Falls, Texas, January 8, 1957. This showed RBC, 4,370,000; WBC, 10,150; HB, 13.5 gm., with normal differential, blood cholesteral 177 mg.; serology negative. Urine negative. The diagnosis of an internist was acute fibrinous pleurisy.

When first seen by J. H. A. in March, 1957, the eye picture was about the same as already described. Because of the history of several attacks of pleurisy, streptomycin and one of the oral drugs for tuberculosis were administered by her internist with no effect. In June, 1957, a course of metacortone was given. There seemed to be a definite improvement in the number of vitreous opacities but little change in her vision.

On July 11, 1957, the patient was seen in Dallas, Texas, in consultation by F. H. N. and R. G. B. This examination showed an edema of retina and ciliary body with numerous vitreous opacities, intact retina bilateral, moderate lens clouding, markedly contracted fields simulating a right homonymous, incongruous hemianopsia. No definite cause for the trouble was suggested. The neurologic examination on July 31, 1957, was negative. The neurologist suggested the possibility of toxoplasmosis.

The next examination on October 24, 1957, showed a decided swelling of each lens with very taut capsules, presumably due to edema, with an associated marked edema of the ciliary bodies. This edema had not been so evident on July 11th. There was considerable clouding of each lens but not enough to prevent a fairly good view of the ciliary bodies. A satisfactory view of the fundi could not be obtained. Vitreous opacities remained about the same. A delayed reaction from metacortone was mentioned as a possible cause. Diamox was suggested to relieve the edema. Visual acuity was: R.E., form projection; L.E., 5/400. Delay in removal of either lens until the edema had subsided was advised, unless intraocular pressure increased. The tension had remained in normal limits during all the time of observation.

On December 11, 1957, the edema had subsided moderately with a slight increase in visual acuity and size of fields. On March 3, 1958, the cataracts were fully developed and the patient had become so upset about her loss of vision, with no satisfactory explanation and delay in getting relief that, on March 4, 1958, an uncomplicated intracapsular cataract extraction with round pupil was carried out in the right eye without waiting for a general check up. The routine blood report made at St. Paul's Hospital, Dallas, Texas, on March 4, 1958, showed HB 6.7 gm., hematocrit, 20 percent. The operation was done despite the anemia for the reasons already mentioned. Her convalescence was uneventful and she returned to the care of J. H. A. in a week. The anemia was attributed to bleeding from her diaphragmatic hernia and blood transfusions were advised.

On April 7, 1958, at Bethania Hospital, the blood report showed HB 6.8 gm. and again on April 9, 1958. Feces showed occult blood on April 9, 1958, and April 11, 1958. Blood transfusions were started on April 7, 1958. On April 12, 1958, HB had risen to 11.2 gm. Diagnosis of diaphragmatic hernia was confirmed by X-ray examination.

On April 15, 1958, corrected vision was: RE, 20/400. On April 16, 1958, an intracapsular extraction was done on the left eye. No complications followed. The blood report at St. Paul's Hospital, Dallas, Texas, on April 16, 1958, was HB 13.9 gm., hematocrit 43 percent; on April 17, 1958, HB 13.9 gm., hematocrit 46 percent; on April 19, 1958, HB 13.7 gm., hematocrit 42 percent.

On May 23, 1958, examination by J. H. A. showed corrected vision to be: R.E., 20/30; L.E., 20/25. The intraocular changes had cleared up, with the fundus in each eye apparently normal.

Examination by F. H. N. on June 26, 1958, showed the same visual acuity as found on May 23, 1958, with a normal field in the left eye and only slight contraction in the right. The fundi appeared normal.

COMMENT

The report of this case was inspired by a recent article by Dr. Frederick Cordes* on

* Cordes, F. C.: Retinal ischemia with visual loss. Am. J. Ophth., **45**:79-88 (Apr., Pt. II) 1958.

"Retinal ischemia with visual loss." The long duration, the source of the bleeding, the development of cataracts, and the final result seemed to make the report worthwhile.

The recovery of vision in this patient was very slow but her ability to overcome her anemia was quite rapid, as demonstrated by her quick response to the transfusions in April, 1958. Her rather sudden loss of vision in November, 1956, and a normal blood count in January, 1957, can only be explained as an interval of relative freedom from hemorrhages from November, 1956, to January, 1957, giving her time to restore the red cell deficiency. It is generally conceded that repeated small hemorrhages are more likely to produce visual changes than a single large loss of blood.

209 Medical Arts Building (1).

DERMOID TUMOR OF THE ORBIT SIMULATING A NEOPLASM*

RODERICK MACDONALD, JR., M.D.
Louisville, Kentucky
AND
JEROME L. BYERS, M.D.†
New Orleans, Louisiana

LITERATURE

Epidermoid tumor was first described in the literature by Cruveilhier[1] and was termed "pearly" tumor because of its highly refractive and nodular surface. Cholesteatoma as a descriptive term was introduced in 1838 by Mueller[2] because of the large mass of cholesterol crystals in the lesion.

The origin of dermoid tumors has been the subject of much discussion. Heimendinger,[3] Cushing,[4] McFarland,[5] Ewing,[6] Coates,[7] Critchley and Ferguson,[8] Love and Kernohan,[9] and Bailey[10] have all concurred in the belief that primary cholesteatomas or dermoids are congenital growths coming from misplaced, aberrant epithelial tissue. However, trauma may be a factor in the production of dermoid tumors, as pointed out by Thacker.[11]

Pfeiffer and Nicholl,[12] in an excellent review, state that in a series of 200 consecutive cases of exophthalmos reported in 1941, these congenital growths comprised four percent of the cases.

Several reports of isolated cases of dermoids or oil cysts affecting the orbit are to be found throughout the more recent literature. Knapp,[13] in an interesting report, analyzed the chemical constituents contained in a dermoid cyst. He found that the oil contained no free fatty acids. It contained 36.2-percent cholesterol and had an iodine number of 124. This seemed to indicate that it consisted mostly of a triglyceride of fatty acids more unsaturated than oleic, the iodine number of cholesterol being 56. It would seem that a fatty acid of iodine number of about 180 was involved, while this oil was entirely soluble in fat contents the solid material was not. The solid material contained 72 percent cholesterol and gave an iodine number of 55. The alcohol insoluble portion was probably protein.

Borley[14] reported a tooth being present within the tumor in his case. Jones[15] in 1935 reported the case of an oil cyst becoming malignant with the patient dying of carcinomatosis.

Palomar,[16] cited by Samuels, described a dermoid cyst of the orbit connected through the lateral orbital wall with a "knapsack-shaped diverticulum under the temporal muscle."

CASE REPORT

History. D. R., a 32-year-old Negress was admitted to the New Orleans Eye, Ear, Nose, and Throat Hospital on November 16, 1956, with a history of a growth beginning in the upper, outer half of the left lid in 1951. A biopsy was made at another hospital early in 1952, and was reported as a lymphangioma of the lid. The lesion slowly increased in size, and the left eye gradually became more prominent than the right. In November, 1952,

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* From the Department of Ophthalmology, Tulane University Medical School, and the Eye, Ear, Nose, and Throat Hospital of New Orleans, Louisiana. This case was reported to the Ophthalmic Pathology Club in 1957 by Dr. James H. Allen.

† Trainee, National Institute of Neurological Diseases and Blindness, Bethesda, Maryland.

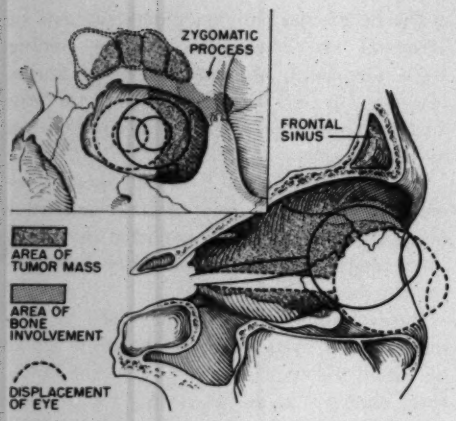

Fig. 1 (Macdonald and Byers). Diagram, showing bony involvement of left orbit and frontal sinus and displacement of left eye.

X-ray studies revealed "a small area of bone erosion in the superior lateral margin of the left orbit which may be secondary to a tumor mass." Surgical intervention was recommended again but the patient refused. There was no other related history.

Ocular examination. The visual acuity was: O.D., 20/20; O.S., 20/200. Examination of the right eye was entirely normal. Examination of the left eye showed moderate ptosis of the left upper lid with bulging of the outer half from the orbital mass. The globe was displaced forward, downward, and nasalward. Ophthalmoscopic examination revealed clear media with an increase in diameter of the retinal veins. The AV ratio was 2 to 5. The nerve-head, retina, and choroid appeared normal. X-ray studies showed a mass in the upper, outer, orbital area and erosion of the upper, outer, orbital wall (fig. 1). The general physical examination revealed no other lesions.

Course. On November 30, 1956, an exploration of the orbit was carried out through a Berke modification of the Krönlein procedure under general anesthesia. After the skin incision was made and the bone flap turned out, a large fungating mass was found which surrounded the globe on the temporal side and extended back to the apex of the orbit. In addition to infiltrating the orbital contents surrounding the extraocular muscles and the optic nerve, it had also eroded through the floor of the frontal sinus, extending through the zygomatic process of the frontal bone into the temporal fossa. Interspersed throughout this mass of granulation-like tissue were oil-filled spaces which contained thick, straw-colored oily material. This tissue extended into and filled the left frontal sinus with the exception of a small portion at the most medial aspect of the sinus.

Although frozen sections taken at this time showed no evidence of malignancy, the orbit was exenterated because of the massive extension and lack of encapsulation of the process. The frontal sinus also was exenterated because it was filled with large masses of oil containing the granulation tissue previously described. The affected lateral wall of the orbit was removed. Tumorlike tissue also was removed from the temporal fossa and a portion of the temporalis muscle was excised. The orbit was packed with rubber dam and vaseline gauze and a pressure dressing applied. The patient withstood the surgical procedure well. There has been no recurrence of the lesion.

Pathology

The gross specimen consisted of several pieces of whitish gray tissue and bone fragments. The tissue apparently was composed of some glandular structures, hair follicles, and cystic spaces part of which contained sebaceous material and part a yellowish brown, thick, oily fluid.

Microscopic examination revealed chronic granulation tissue containing sebaceous glands, hair follicles, smooth muscle fibers, and epidermal-lined cystic spaces filled with keratin, epithelial debris, and many cholesterol crystals (fig. 2).

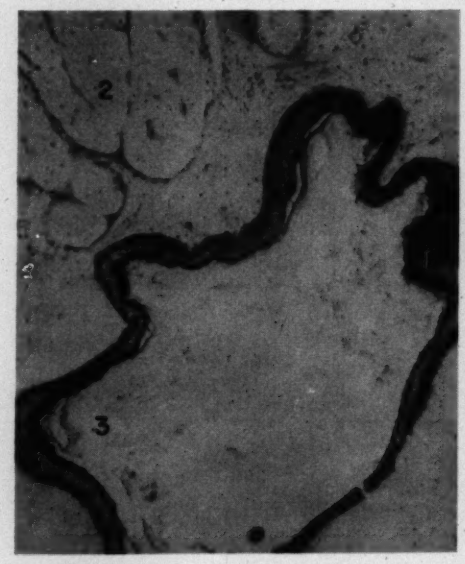

Fig. 2 (Macdonald and Byers). Low-power view of dermoid cyst, showing sebaceous glands, hair follicle, epithelial layer, and desquamated epithelial products. (×100, hematoxylin-eosin.) (1) Cross section through hair follicle. (2) Sebaceous gland structure. (3) Desquamated epithelial products.

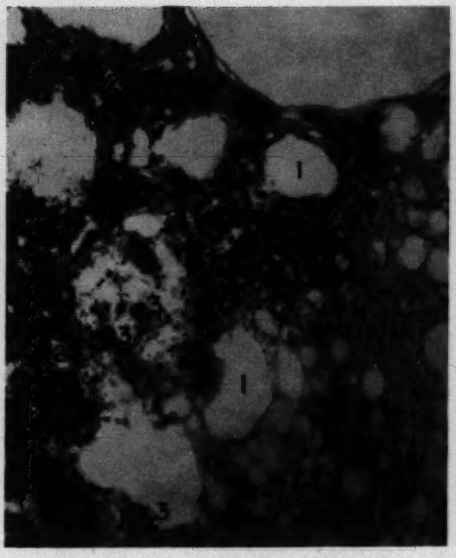

Fig. 3 (Macdonald and Byers). Section of orbital tissue involved by dermoid cyst, showing (1) large oil-filled spaces, (2) lacrimal gland tissue, (3) foreign body giant cells. (×100, hematoxylin-eosin.)

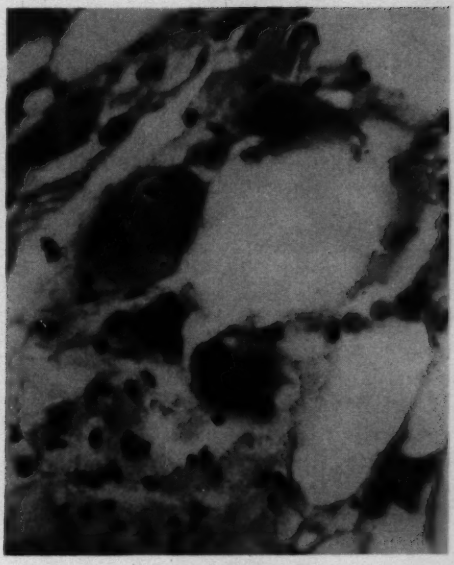

Fig. 4 (Macdonald and Byers). Large oil-filled spaces within the dermoid cyst, showing surrounding epithelioid foreign body giant cells and lymphocytes. (×430, hematoxylin-eosin.)

The oily fluid of the dermoid cyst evoked a marked foreign body giant cell reaction within the cyst and wherever it had escaped into the surrounding orbital tissue (fig. 3). Foreign body type giant cells were found predominantly around oil globules, represented on the microscopic sections as empty tissue spaces (figs. 4, and 5). A moderate lymphocytic reaction also was present. The capsule of the cyst could not be identified with certainty, indicating the wide-spread rupture of the cyst which accounted for dispersion of its irritating oily content.

Discussion

This case of dermoid tumor of the orbit is reported because of its clinical and surgical resemblance to a true orbital neoplasm by extensive invasion of the frontal sinus and extension through the lateral orbital wall into the temporal muscle.

In retrospect it must be assumed that the biopsy made in 1952 was not deep enough to obtain the characteristic lesion and resulted

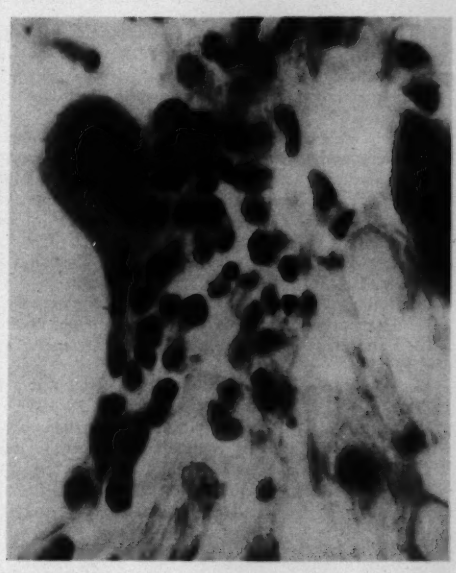

Fig. 5 (Macdonald and Byers). Foreign body giant cell at the periphery of oil-filled space. (×970, oil hematoxylin-eosin.)

only in removal of surrounding tissue. In the interval the tumor mass increased in size and one or more of the oil-containing cysts ruptured, producing a diffusely infiltrating granulomatous reaction. This type of reaction which resembles that of a chalazion has been reported previously by Reese[17] and others.[18]

Although the oil reaction is more commonly found with dermoids in other locations, it occurs frequently enough in the orbit, and bone destruction occurs so frequently that complete surgical excision of orbital dermoids is recommended at the earliest practical time.

Carey[19] recently reported five epidermoid and two dermoid orbital tumors which extended into the cranial cavity requiring removal by the transcranial route. These cases as well as the one reported emphasize the serious extensions which may arise from a lesion ordinarily considered to have only local significance. Therefore, early removal is indicated when an orbital approach offers adequate exposure with relatively little risk to the patient.

Summary

A case of dermoid tumor and cyst of the left orbit in a 32-year-old Negress has been presented.

The outstanding clinical features of this case are:

1. A slowly growing tumor mass in the left upper, outer, orbital area.
2. A painless proptosis of the left eye with decrease in visual acuity.
3. Extensive involvement of the left orbit, erosion and invasion of the left frontal sinus, and extension through the frontal bone into the temporal fossa.
4. Total surgical excision and exenteration of all involved structures through a Berke modification of the classic Krönlein incision has apparently proven satisfactory in this case, as no recurrence has been noted.

323 East Chestnut Street (2).
1430 Tulane Avenue.

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SUTURE IN SCLERA FOR ZONULOTOMY*

TUTOMU SATO, M.D.
Tokyo, Japan

In intracapsular extraction of an immature cataract in relatively young persons, one often meets with difficulty in rupturing the zonules. When this occurs, I press the cornea at the 6-o'clock position with the point of Amenaber's hook while applying traction on the sclera with the suture described.† The pressure on the cornea combined with tension on the suture makes rupture of the zonules very easy.

This method of zonulotomy can be performed either before or after applying the erisophake or lens forceps. If it is performed before, the surgeon can pull the suture with his left hand. If it is performed after traction on the lens is initiated, the assistant should pull on the suture. Once the zonules at the 6-o'clock position are ruptured in this way, the other zonules will be easily broken by pressure with the hook without traction on the suture.

When I first conceived using this method of zonulotomy, the thought foremost in my mind was the fear of bringing about a choroidal or retinal detachment. Complications of this kind have not occurred to the present in a total of 50 cases. Furthermore, this method has never retarded restoration of the anterior chamber. In view of these facts, it seems quite harmless.

When zonulotomy is difficult and traction on the suture is required, it is a sign that the ciliary body and the tissues near it are healthy and traction on the suture will not cause complications. On the other hand when the zonules are weak and rupture easily, pulling on the suture is not required. When my method is used for difficult zonulotomy on senile cataract only, and not abused on younger patients, in advanced myopia, and so forth, it is my belief that there will never be any complications.

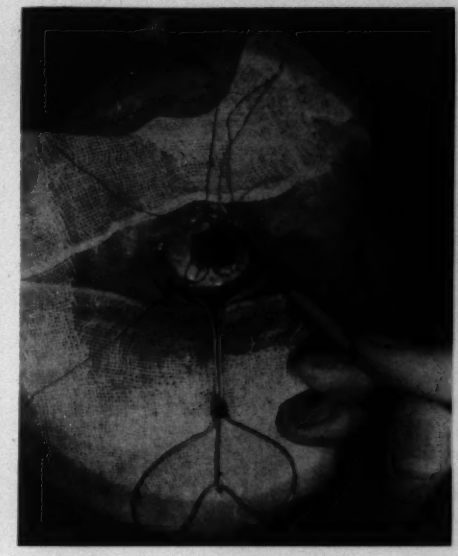

Fig. 1 (Sato). Zonulotomy with the use of a suture on the sclera.

I have thought of using two or more sutures for zonulotomy and pulling on them one after the other or pulling on two sutures placed on opposite sides of the limbus. At present, however, I do think the method herein reported can not be improved upon.

Juntendo University Medical School.

* From the Department of Ophthalmology, Juntendo University Medical School.

† Sato, T.: Flexible refractor. Am. J. Ophth., **47**: 692 (May) 1959.

CILIARY BLOCK WITH BENZOCAINE*

IN PAINFUL BLIND EYES

S. P. MATHUR, M.S.
Bharatpur (Rajasthan), India

A mixture of 2.5-percent Benzocaine with 0.5-percent quinine urea hydrochloride has been used by various workers for prolonged local analgesia. Mathur and Mistry[1] (1956)

* From the Department of Ophthalmology, Victoria Hospital.

used it as nerve block for relief of postoperative pain in general surgery. Dastoor[2] (1955) used it to prolong akinesia in ocular surgery with great satisfaction and claimed it to be of immense value especially in intracapsular cataract extraction and keratoplasty. My predecessor in this hospital used Benzocaine on the lines of Dastoor on over 200 cases of cataract extraction (exact figures not known). At least seven of these patients still attend the hospital with complete facial paralysis, insensitive cornea, and exposure keratitis even a year and a half after operation. After observing the profound action of Benzocaine, I planned to use this for ciliary block in patients with painful blind eyes who refused enucleation.

Mechanics of prolonged action

The solution of Benzocaine is saturated. Dilution with water or contact with tissue fluids results in the precipitation of Benzocaine in microcrystalline form. A "depot" is thus formed from which active agent slowly absorbs, resulting in a prolonged but strictly localized analgesic action.

Method and dose of injection

The following precautions were observed while giving injections (Kohn, et al.,[3] 1954):

1. Syringe and needle must be completely dry. Even small amounts of water can cause precipitation of Benzocaine, blocking the needle and causing inaccuracy in dosage.

2. Injection into the skin or the tract must be carefully avoided.

3. Usually one cc. is sufficient. As the purpose of injection is essentially a "depot" formation, larger doses will be useless or may even cause tissue reaction, as the solution used is saturated.

A retrobulbar injection of two cc. Benzocaine solution was administered in every case with a four-cm. thin BD needle.

Results

Table 1 analyzes 50 cases in which Benzocaine was injected. It was noted that the pain disappeared by the time the injection was completed. The eye was dressed, an ointment used, and the patient sent home. He was asked to report back if pain recurred. One patient who was injected for a painful phthisical eye after an extensive corneal ulcer returned after five months complaining of proptosis and chemosis for about a week—but no pain. He developed panophthalmitis for which evisceration was done without any further retrobulbar anesthesia. Slight fullness in the orbit which subsided within a couple of days was visible in four cases and one case required repetition of the injection.

For the purpose of comparison with the standard technique of retrobulbar alcohol injection, 0.5 cc. of absolute alcohol was given five minutes after 1.5 cc. of two-percent Novocaine in 20 cases. Analysis of these

TABLE 1

Analysis of group administered benzocaine

Diseases	No. of Cases	No. of Cases in Which Benzocaine was Repeated for the Second Time	No. of Cases Showing Complications
Postoperative cyclitis	18	In one case after 3 da.	2 cases slight fullness of orbit for 2 da.
Absolute glaucoma	23	No	1 case slight fullness of orbit for 1 da.
Staphyloma	3	No	None
Injury	2	No	None
Postulcerative phthisis bulbi	4	No	1 case slight fullness of orbit for 2 da. 1 case eviscerated after 5 mo.

TABLE 2

ANALYSIS OF GROUP ADMINISTERED ALCOHOL

Disease	Cases	No. of Cases in Which Alcohol was Repeated for the Second Time	No. of Cases Showing Complications
Postoperative cyclitis	6	3	2 cases chemosis+proptosis, 2 da.
			1 case chemosis+proptosis, 5 da.
			1 case chemosis+proptosis, 8 da. after which eyeballs sank; limitation movements
			1 case chemosis for 3 da.
Absolute glaucoma	4	None	3 cases chemosis for 4 da.
Staphyloma	4	1	None
Injury	6	2	3 cases chemosis for 3 days

cases is given in Table 2. It is to be noted that six of these cases required a second injection. All these cases were kept under observation for complications for at least a week. Chemosis and proptosis developed in 11 cases, out of which one developed sinking and limitation of movements of the eyeball due to retrobulbar fibrosis.

DISCUSSION

It is evident that the standard technique of retrobulbar injection of alcohol for painful blind eyes is not satisfactory. The technique is cumbersome in view of the fact that Novocaine is first injected to anesthetize the area and then, after five minutes, alcohol is injected through the same needle.

Alcohol irritates the local tissues and gives rise to proptosis, chemosis, and retrobulbar fibrosis. It also becomes diluted and, therefore, its sclerosing effect on the ciliary ganglion is not always complete. Benzocaine is free from these disadvantages.

Its administration is easier. It does not produce local irritation and, therefore, cause complications such as chemosis and proptosis, although a dose of more than one cc. can give rise to tissue necrosis, as suggested by Mathur and Mistry (1956). The "depot" formation gives a prolonged action lasting for several months.

Results with Benzocaine are more sure, as noted by the fact that only one out of 25 cases required a second injection, six of 20 cases of the alcohol series required a second injection.

SUMMARY

A mixture of 2.5-percent Benzocaine with 0.5-percent quinine urea hydrochloride was used for ciliary block in 50 cases of painful blind eyes and the results compared to 20 cases in which absolute alcohol was used in the similar way. It was noted that the effect of the Benzocaine injection was more lasting and not accompanied by such complications as chemosis, proptosis, and retrobulbar fibrosis which are likely to occur after alcohol injection. The dose, method of injection, and mode of action of Benzocaine are discussed.

Victoria Hospital.

ACKNOWLEDGMENTS

I wish to thank Mr. Mody of Unichem Laboratories for supplying samples of Benzocaine free of cost. I thank P. M. and H. O. Bharatpur for their kind permission to publish this report.

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SIMPLIFIED DOUBLE-EDGE KNIFE*

A. Benedict Rizzuti, M.D.
Brooklyn, New York

Within the past several years both scleral resection for retinal detachment and keratoplasties, penetrating and lamellar, have become more readily accepted by a greater number of surgeons.

To simplify further the surgical techniques, and for expediency, a special simplified double-edge knife was devised.† The body of the knife measures 3.75 inches in length, is easily held by the fingers, and rests comfortably in the palm of the hand. A screw mechanism on the body regulates the desired amount of mm. separation of the cutting edges. Measurement is made directly on a caliper. The cutting edges consist of two small, sharp, rounded, removable blades that can be easily inserted and fastened in a set position by two individual thumb screws. The blade edge is shaped similar to a Gill knife which prevents any undue perforation of the cornea or sclera. It becomes quite simple to cut either along a straight line (keratoplasty) or on a deep curve (scleral resection). The removable knife blades can either be sharpened or simply replaced by new ones at a minimal cost.

The knife was found to be particularly useful in mapping out and cutting a three or four-mm. scleral strip in lamellar scleral resection. It has also been used for square or rectangular penetrating or lamellar corneal grafting. In circular lamellar keratoplasties one knife edge can be inserted for the corneal dissection when removing the diseased recipient corneal tissue. Its use has also been found practical for marking the proper site on the sclera, in muscle surgery, for the insertion of sutures.

In conclusion, this simple double-bladed knife possesses the distinct advantages of being light, easy to handle, able in making a quick change of obtainable sharp blades and versatile in its use in ophthalmic surgery.

160 Henry Street (1).

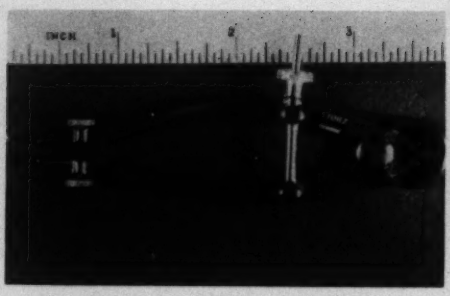

Fig. 1 (Rizzuti). Simplified double-edge knife for use in scleral resection or keratoplasties

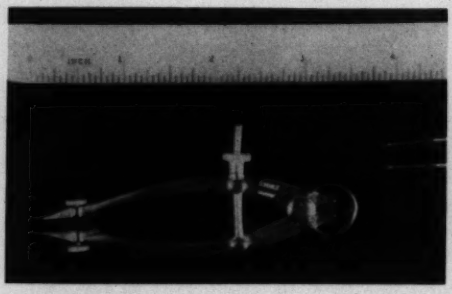

Fig. 2 (Rizzuti). Knife, showing removable round-edge blades.

* Used in the Corneal Clinic, Brooklyn Eye and Ear Hospital.

† This instrument may be obtained from the Storz Instrument Company, 4570 Audubon Avenue, St. Louis 10, Missouri.

MODIFICATION OF TUDOR-THOMAS METAL STAND*

P. K. Basu,† D.O.M.S., and H. L. Ormsby, M.D.
Toronto, Ontario

The Tudor-Thomas metal stand has been modified to facilitate the introduction of the suture attached to the optic nerve of the donor eye.

A vertical slit has been sawed through the body of the stand to meet the hollow central core. The suture can be drawn through this

* From the Department of Ophthalmology, Faculty of Medicine, University of Toronto.

† Department of Ophthalmology, Ramakrishna Mission Sevashrama, Vrindaban, U. P., India.

Fig. 1 (Basu and Ormsby). Tudor-Thomas metal stand modified, showing vertical slit.

Fig. 2 (Basu and Ormsby). Drawing the suture through the slit from the outside.

slit from the outside, avoiding the present necessity of threading it through the core from end to end (figs. 1 and 2).

3050 Yonge Street.

THE HOMEOSTATIC REFLEX*

In the regulation of the intraocular pressure

Paul Weinstein, M.D.
Budapest, Hungary

It is known that the intraocular pressure is one of the rhythmic constants of the organism, as are the blood pressure, the temperature, urination, and so forth. The constant regulation of the ocular tension is by a homeostatic reflex. This reflex begins to function as soon as any autogenous or exogenous factor attempts to change the intraocular pressure, and becomes stabilized when the production and outflow of aqueous are in balance. If aqueous production decreases, the resistance at the angle increases —and vice versa.

Strictly speaking, the homeostatic reflex is neurovascular. It is an elastotonometric reflex, as described by Kalfa (fig. 1). To illustrate: If the applanation tonometer of Maklakoff is loaded with gradually increasing weights, each increase will result in greater and greater pressure within the eye. This is because the intraocular fluids—as with any other contained fluid—can neither be compressed by nor escape from the force produced by the weight on the globe. While the pressure of the tonometer is increasing, the ocular tension, the neurovascular reflex, is attempting to decrease the ocular tension (Kalfa). In a normal healthy eye, this neurovascular mechanism is capable of balancing the outside pressure with the inside pressure which does not go beyond 12 mm. Hg. However, in eyes suffering from glaucoma, the mechanism does not function properly and the pressure of these diseased eyes shows significant increase.

That the neurovascular reflex does, however, strive to operate even in eyes suffering from glaucoma may be observed during an acute attack. Frequently, after such an attack, the eye becomes hypotensive. That this is due to a so-called cessation of secretion may be shown by a seeming increase in fluorescein permeability after the attack (fig. 2). The reason the permeability only seems to increase—it actually does not—is that the fluorescein is more highly concentrated in the aqueous as a consequence of the cessation of secretion which accompanied the attack.

That the homestatic reflex is able to

* From the Department of Ophthalmology, The Medical Postgraduate Institute of Szabolcs Utca.

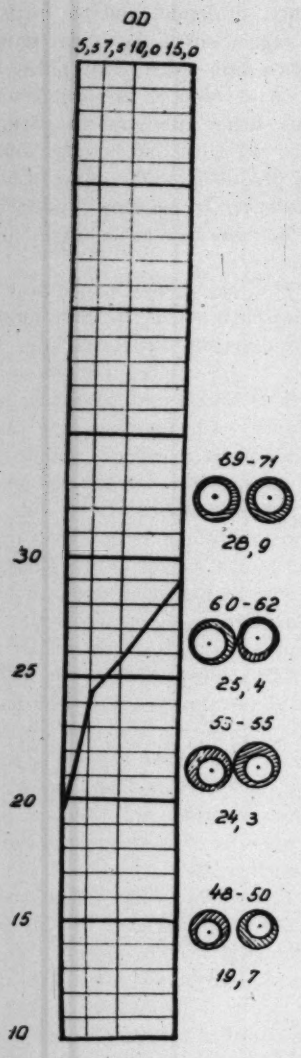

Fig. 1 (Weinstein). The elastotonometric reflex measurements. (After Kalfa.)

stabilize the ocular tension, after therapy to reduce the pressure, is due to an increase in angle resistance. In their experiments, Becker and Constant observed so-called pseudoresistant cases in rabbits after administration of Diamox. There was no change in ocular tension because the resistance of the angle was double, balancing the decrease in secretion (fig. 3).

Diurnal fluctuations in the quantity of aqueous in normal persons has been measured by Rosengren's suction cup by Dr. Erickson in the eye clinic at Göteborg. The highest secretion (0.8 ml.) was observed at eight o'clock in the morning. It decreased thereafter, becoming least (0.23 ml.) at dawn (four o'clock in the morning). During this entire time, the intraocular pressure had changed only minutely.

On the basis of some of his experiments, Linnér suggests that the resistance of the angle also changes during the day, being highest during the hours of dawn; lowest later in the morning. Stepanik has reported similar observations. Weinstein and Forgács have shown that, in normal persons, the systemic venous pressure is lowest in the morning hours; in glaucomatous persons, it is highest.

Pommer and Eberhartinger made an interesting observation during their study of contusions of the globe. They reported that the ocular tension showed no change in any of their contusion cases. Immediately after the contusion, permeability decreased as a result of vasoconstriction; later, however, there was an increase of permeability because of vasodilatation.

Kayegama has confirmed the observation

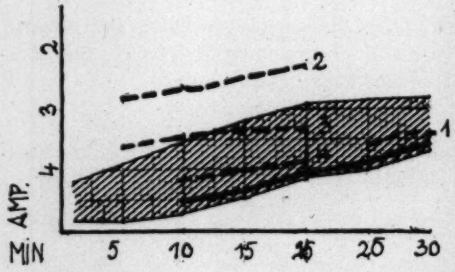

Fig. 2 (Weinstein). An acute glaucomatous attack in a left eye. (1) During an attack. (2) Immediately after an attack. (3) One week after an attack. (4) Three weeks after an attack. (Continuous line, permeability of the nonglaucomatous right eye.)

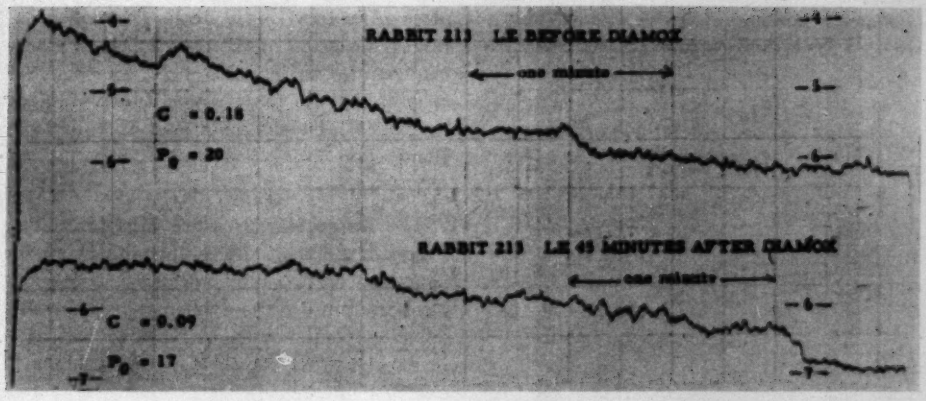

Fig. 3 (Weinstein). Pseudoresistant rabbit. Tonographic tracings before (above) and after (below) the systemic administration of acetazolamide (100 mg./kg., intravenously), demonstrating a compensatory decrease in facility of outflow (C) resulting in little fall in intraocular pressure (P_o) in spite of suppression of secretion. (After Becker and Constant.)

that angle resistance decreases as the minute volume of aqueous increases after the water-drinking provocative test in nonglaucomatous persons. However, in glaucoma the increase of aqueous secretion is not compensated for by a decrease in angle resistance.

According to our present knowledge regulation of the intraocular pressure depends on the cortex, diencephalon, ciliary ganglion, the recently described receptors, and terminal nerve endings. In animal experiments Vrabec has proved the presence of sensory corpuscles at the border of the ciliary processes and the trabecula (fig. 4). Kurus has demonstrated sensitive nerve fibers with free ends in the trabecular meshwork (fig. 5). These data have been confirmed by Holland, von Sallmann, and Collins. By these workers, the

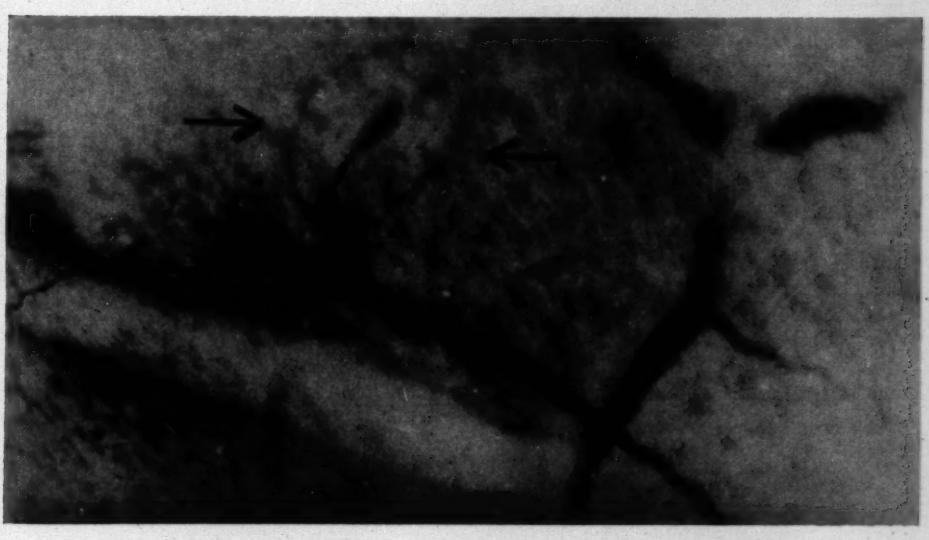

Fig. 4 (Weinstein). Sensitive body in the trabeculum. (Courtesy of Vrabec.)

Fig. 5 (Weinstein). Nerve ending in the trabeculum. (Courtesy of Kurus.)

anatomic and morphologic bases of the homeostatic reflex are explained. Changes in the intraocular pressure produce so-called interceptor signals to both the cortex and diencephalon, with the consequence that the mechanism secreting aqueous starts to function as does the mechanism which produces changes in angle resistance, provided, of course, that the physiologic functioning of the neural elements undergoes no pathologic change.

Summary

The intraocular pressure is stabilized by means of a homeostatic reflex which controls aqueous secretion and angle resistance. Aqueous secretion decreases when any autogenous or exogenous factor attempts to raise the ocular tension; conversely, any attempt to decrease the tension is followed by a rise in angle resistance. This homeostatic reflex is controlled by the sensitive nerve elements found in the trabecular meshwork of the angle, which send interceptive signals to the cortex, diencephalon, and the ciliary processes. When pathologic interference disturbs the normal functioning of the homeostatic reflex, glaucoma results.

V. Balassi Bálint u. 9/11.

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OPHTHALMIC RESEARCH

EDITED BY FRANK W. NEWELL, M.D.

Abstracts of papers presented at the meeting of the Midwest Section of the Association for Research in Ophthalmology, Inc., Denver, Colorado, April 18 and 19, 1959.

T. F. SCHLAEGEL, JR., M.D., Indianapolis, Indiana
Section Secretary

Autonomic conditioning in hysterical amblyopia. R. A. Wagoner, Ph.D., and T. F. Schlaegel, Jr., M.D., Department of Ophthalmology, Indiana University School of Medicine, Indianapolis.

Using the presence or absence of conditioning as a criterion, it was determined that patients with tubular fields were able to respond to lights presented in the consciously "blind" peripheral area. It was found that this reaction increased the degree of anxiety as suggested by the increased galvanic skin response in tubular field subjects, the moderately high level of anxiety on the Taylor Manifest Anxiety Scale after the experiment, and the increased resistance to extinction of the conditioned response. We postulate that the reason for this increase in anxiety may lie in the patient's recognition that he has been caught in a process of unconscious malingering.

Retention and interocular transfer of intensity discrimination in dark-reared kittens after ablation of visual cortex. Louis Aarons, Ph.D., Department of Neurology and Psychiatry, Northwestern University Medical School, Chicago, and Austin H. Riesen, Ph.D., Psychology Department, University of Chicago.

Kittens deprived of pattern vision but given binocular diffuse-light stimulation are retarded in learning and fail to show ocular equivalence for monocular form and movement discriminations. In contrast, these subjects, as well as cats without visual cortex, readily learn intensity discriminations, the former also exhibiting prompt interocular transfer of the habit. These data suggested the possibility of an independent and perhaps initial organization for intensity habits and their ocular equivalence at subcortical levels.

Our study examined the effects of a lack of visual experience and ablations of visual cortex on learning, retaining, and transfer of a monocular intensity discrimination. Kittens born and reared in total darkness or in the lighted laboratory were trained and tested before and after cortical ablation.

Results showed that, contrary to expectations, the dark-reared as well as pattern-experienced kittens lost the discrimination habit after cortical ablation. After relearning the habit using the same eye as before operation, both groups showed prompt interocular transfer. Unoperated controls also showed immediate transfer. We conclude that visual intensity discrimination habits show interocular equivalence at both the cortical and the subcortical levels when the habits have been learned monocularly by kittens without any prior light experience through the test eye.

The electroencephalogram in retinitis pigmentosa. Alex E. Krill, M.D., and Frederick W. Stamps, M.D., University of Illinois College of Medicine, Chicago.

A study of 32 retinitis pigmentosa patients was undertaken to see whether any characteristic patterns could be related to these patients on the basis of a complete electroencephalographic evaluation and if any diagnostic value could be ascribed to this test.

A monopolar recording technique with the ears as reference points and with silver disc electrodes fastened to the scalp in at least eight different areas was used. Sleep records were obtained in addition to awake records in all cases but one. Alpha blocking was noted in this study and hyperventilation, which was done in 12 cases, consisted of 50 breaths a minute for two minutes.

In this study five records were considered to be mildly abnormal and showed 14 and six per second positive spikes or six per second spike and wave seizure patterns. Two records were considered abnormal and revealed long runs of diffuse slow waves primarily during drowsiness in one record and spike and wave seizure discharges in the other record. All of the abnormalities in the present study were noted primarily during sleep and drowsiness and were considered diffuse in nature. These characteristics suggested subcortical disturbances.

In the classification based on alpha amplitude 25 records were considered in the category of good or prominent alpha, six in the category of low-voltage alpha, and one in the category of flat. A comparison of this group with normal population controls revealed no significant difference in regard to percentage of low voltage or flat records.

Hyperventilation and alpha blocking were of no value.

Previous studies reported a higher percentage of abnormalities; however, an analysis of these

studies revealed that differences in interpretation of records and selection of patients were important factors in comparison of results.

No definite pattern could be ascribed to retinitis pigmentosa patients because of the diverse abnormalities noted in this series (four different patterns) and in previous reports. This variation may be related to a possible diversity of the group of diseases called retinitis pigmentosa.

No relationship could be established in our study or any of the preceding reports between the severity of the disease and the presence of what was considered to be an abnormality.

The electroencephalogram was thought to be of no proven value in the differential diagnosis of tapetoretinal degenerations.

The electromyography of vergence movement. James E. Miller, M.D., Washington University School of Medicine, Saint Louis.

Electromyography of convergence demonstrated a spindle-shaped pattern with increasing activity of 0.1 second followed by a decline of as much as a second in the medial rectus. The lateral rectus demonstrated reciprocity throughout.

Divergence was found to have two forms in which the first showed a saccadic burst in the medial rectus with a simultaneous rise of activity in the lateral. The second type was entirely saccadic with a sudden increase in the lateral followed by numerous secondary alterations between medial and lateral rectus.

Convergence contains more motor units than a version movement of the same amount, and part of the motor units are different.

Asymmetric convergence is accompanied by saccadic bursts in yoke muscles and then the convergence pattern in both medials. If an object is slowly approximated in front of one eye, no increase in coactivity is observed until the near point of convergence is approached. The coactivity was believed to represent the beginning of divergence.

Endocrine ophthalmoplegia. R. O. Schultz, M.D. Department of Ophthalmology, University Hospitals, M. W. Van Allen, M.D., Section of Neurology, Veterans Hospital, F. C. Blodi, M.D., Department of Ophthalmology, University Hospitals, Iowa City, Iowa.

Ophthalmoplegia was found to occur in 14 percent of 165 patients with thyrotoxicosis, with an incidence of 22 females and one male. Its occurrence appears to be related to the thyrotoxicosis rather than to the exophthalmos, both in time of onset and response to therapy.

Approximately 50 percent of the patients with ophthalmoplegia experienced return of normal eye movements following control of their thyrotoxicosis; and this occurred in spite of the fact that proptosis may have increased following the use of radioactive iodine.

Thyrotoxic ophthalmoplegia for some unknown reason seems to have marked predilection for the superior rectus and inferior oblique muscles.

Myasthenic symptoms in addition to the ocular manifestations occurred in three of 23 patients with ophthalmoplegia and thyrotoxicosis. The ocular as well as the generalized signs of myasthenia disappeared with control of the toxicity.

Electromyography obtained in thyrotoxic ophthalmoplegia persisting after control of thyroid function showed a pattern consistent with a primary myopathy.

Electromyography done during the acute phase of a case of nonthyrotoxic, congestive exophthalmos showed a neuropathic pattern. A biopsy of the external rectus muscle revealed essentially normal muscle tissue, and histochemical staining for acid mucopolysaccharides was negative.

On the production of cataracts by the intralenticular injection of certain enzymes and enzyme inhibitors. David Shoch, M.D., Department of Ophthalmology, and E. A. Zeller, M.D., Department of Biochemistry Northwestern University Medical School, Chicago.

Adopting the recently published method of A. W. Vogel and D. A. Reinoehl, of injecting fluids into the lens, we deposited enzymes and enzyme inhibitors into the lens. With 2.5 micromoles of iodoacetate a permanent subcapsular cataract was produced in the rabbit eye within three days. About the same time opacities appeared following the administration of 0.1 to 0.2 mg. of crystalline ribonuclease or chymotrypsin. In three forms of cataract (human senile cataract, x-ray induced cataract in rabbits, iodoacetate cataract) a significant drop of a cathepsin C-like enzyme, described previously by E. A. Zeller and A. Devi, has been observed. The degree of reduction seems to be parallel to the size of the opaque volume. This may be the reason why the drop in the PAA-HY activity caused by the injection by ribonuclease and chymotrypsin has not become significant as yet.

During all processes of cataract formation so far studied the protein content of the lens drops. By a feedback operation of unknown mechanism the proteinases adjust to this situation by reducing their activity. When the production of energy required for protein synthesis is suppressed by interrupting the glycolytic chain with the help of iodoacetate or when the protein synthesis is prevented by the destruction of the nucleic acid template, then the catheptic activity is lowered by adaptation.

Histology of zonulysis with alpha-chymotrypsin. Albert P. Ley, M.D., Ake Holmberg, M.D., Tsuyoshi Yamashita, M.D., Washington University School of Medicine, Saint Louis.

Rhesus monkey eyes in vivo and enucleated human eyes obtained from autopsies were used for these experiments. Following treatment with

alpha chymotrypsin the eyes were fixed promptly and sections were studied by either light or electron microscopy.

The significant findings include:

The zonule in the normal human eye appears to be approximately one micron in thickness and composed of very densely packed uniform fibrils of approximately 60-70 Å in thickness. These fibrils all appear to be oriented longitudinally and separated by a less osmophillic ground substance. Our preparations do not demonstrate any banding or periodicity in these fibrils nor does their structure resemble what has so far been accepted as the electron microscopic configuration of collagen. Study of the lens capsule at the equator suggests that it is made up of three distinct layers, the outermost of which may be a continuation of the zonular fibers.

The anterior segments of eyes treated with alpha chymotrypsin demonstrate a dilatation of the ciliary ring. Under the lytic action of alpha chymotrypsin the long regular fibrillar structure of the zonule appears to break down into clusters of fragments of relatively uniform length and arrangement. The entire outer layer of the lens capsule is no longer demonstrable in the enzyme treated eyes.

The internal limiting membrane and the ciliary epithelium appear unchanged in the same specimens in which lysis of the zonules and pericapsular membrane is demonstrated.

These preliminary studies suggest that alpha chymotrypsin causes a selective lysis of zonules and pericapsular membrane.

The effect of alpha-chymotrypsin (Quimotrase) on the rabbit eye. Jon C. Thorson, M.D., and P. J. Leinfelder, M.D., Department of Ophthalmology, University Hospitals, Iowa City, Iowa.

Alpha-chymotrypsin in a 1-2500 solution was placed in the anterior chamber of sixteen albino rabbit eyes and an equal amount of normal saline in four control globes. The eyes were enucleated nine weeks later. Gross and microscopic examination of all globes revealed no morphological difference between the normal and control eyes and except for the gross presence of one peripheral retinal hemorrhage in an enzyme-treated eye, no pathologic changes were found.

Contractile forces in iris of cats. Julia T. Apter, M.D., Department of Ophthalmology, Northwestern University, Chicago.

The crucial test for locating muscles in the iris is the physiologic one—the development of active tension in response to appropriate stimulation. It was the purpose of the present study to explore the distribution of contractile forces in the iris of cats using this physiologic test.

The eyes of cats were removed under nembutal anesthesia and the cornea was immediately cut away 1.5 mm. behind the limbus. Following this procedure the pupil assumes the shape of a narrow oval.

The iris in the 6- and 12-o'clock positions is termed "apical iris" and in the 3- and 9-o'clock positions the "lateral iris." Slits 1.0 mm. long were cut through the thickness of the iris in the radial and circumferential directions in three different areas: the sphincter area, root area and intermediate between them. The iris segment extending 2.0 mm. around each slit was excised. Apical and lateral iris segments were considered in two separate groups.

The excised segments were suspended horizontally between two hooks in a bath containing an artificial medium. One hook could be manipulated laterally to induce stretch. The other hook was attached to the lower free end of a straight ribbon of spring steel the upper end of which was firmly fixed. Displacement of the free end of the spring displaced a beam of light reflected from a mirror attached to the spring. This system was calibrated with weights over the range of 10 to 100 mg. the range appropriate to active forces developed by iris segments.

Fifteen minutes after the segment was placed over the hooks, it was stretched carefully by means of the adjustable support until a small resting force of 20 to 25 mg. was registered by the strain gauge. Stimulation consisted in adding mecholyl or adrenalin to the surrounding medium or in applying electric stimulation via the two supporting hooks connected to a Grass stimulator. Each drug was applied in graded doses and the steady state tension induced by each dose was recorded to obtain a dose-response curve. For electrical stimulation the Grass stimulator supplied a 60-cycle alternating current of graded voltage. Here too, the steady state contractile force was measured and plotted against the stimulating voltage.

A cross-section of the lateral iris shows that the sphincter pupillae was present in the specimens taken from the portion of the iris nearest to the pupil. There are numerous circumferential fibers in this muscle and also some radial fibers in its spoke bundles. In the middle region there is only the dilator pupillae with alleged muscle fibers running radially. In the root region of the cat iris the fiber bundles of the ciliary muscle are arranged circumferentially as well as radially. By placing slits in pupillary, root and intermediate portions of the lateral iris, the contractions of fibers of sphincter, ciliary and dilator muscles were tested separately. What is more, the contractile power of the several muscles could be quantitatively compared since the specimens were of similar size and all were tested at the same resting tension.

The amplitude and direction of contractile forces found was commensurate with the density, location, and orientation of bona fide muscle fibers in the iris. Radial forces in the pupillary portion implicate the radial spoke bundle of the sphincter pupillae. Similarly, in the root the identifiable radial contractility is probably due to action of the radial ciliary muscle. The circumfer-

ential contractility implicates the numerous circular sphincter and ciliary muscle fibers. What is more, the greater forces in the sphincter at the apex of the pupil suggest a greater density of circumferential fibers here, perhaps explaining the oval pupil of the cat. On the other hand, in the intermediate region where only dilator pupillae were present, there was no evidence of contractility at all.

The fine structure of ciliary epithelium. Ake Holmberg, M.D., Department of Ophthalmology, Washington University School of Medicine, Saint Louis.

A comparison of the ultrastructure in rabbit and human ciliary epithelium is presented. In some respects there are remarkable differences between the two species. In the rabbit the external and internal limiting membranes are poorly defined basement membranes usually not more than 300-400 Å thick. In man, however, the same membranes are remarkably different. The human external limiting membrane is a homogenous relatively dense layer several microns in thickness. It sometimes occupies the entire space between the capillary wall and the pigment epithelium. On the other hand, the internal limiting membrane in man consists of a meshwork several microns in thickness. The meshes are limited by their anastomosing bands which usually appear empty. Occasionally the meshes are filled with a dense material.

The structures discussed are compared with the results obtained by histochemical studies (Yamashita, Cibis and Becker). These show that the human external limiting membrane stains with PAS and the internal limiting membrane is both Alcian blue and PAS positive.

Histochemical studies of the ciliary body. Tsuyoshi Yamashita, M.D., Paul Cibis, M.D., and Bernard Becker, M.D., Department of Ophthalmology, Washington University School of Medicine, Saint Louis.

Histochemical studies of the human ciliary body revealed the following points:

1. The internal limiting membrane (membrana limitans internal).

The ciliary body including pars plana and ciliary processes is covered by a relatively thick continuous membrane which stains with PAS, colloidal iron and Alcian blue. The colloidal iron and Alcian blue staining material are largely removed by incubation with testicular hyaluronidase.

Incubation of monkey ciliary bodies in radioactive sulfate followed by radioautography of the sectioned tissue revealed positive incorporation of sulfate into the internal limiting membrane.

2. The pigmented epithelium.

The pigmented epithelium of the ciliary body after depigmentation stains with Alcian blue or iron.

3. The basement membrane (lamina vitrea).

The ciliary process exhibits a thick basement membrane (two to six microns) between pigmented epithelium and the capillaries.

Studies of the effects of cholinergic organic phosphates on the eye: A preliminary report. Maurice Kadin, M.D., and Kenneth P. DuBois, Ph.D., Departments of Ophthalmology and Pharmacology, University of Chicago, Chicago.

The present investigation was initiated to ascertain the possible usefulness of some new organic phosphates for the production of miosis and tension-lowering action in glaucoma. The results of these studies indicate that the oxygen analogue of Co-Ral (diethyl-0-3-chloro-4-methyl-7-coumarinyl phosphorothionate) (Bayer) has properties which make it worthy of consideration for clinical use in the symptomatic treatment of glaucoma. The pharmacology of this compound had not been studied previously and it has no insecticidal use, but Co-Ral, from which the oxygen analogue is derived by chemical oxidation, is used for the control of ecto-parasites including cattle grubs, screw-worms, ticks and lice. Our studies indicated that the oxygen analogue of Co-Ral is a potent anticholinesterase agent. The oxygen analogue is the principal metabolite of Co-Ral, which is activated in the liver by replacement of the sulfur by an oxygen atom to produce the oxygen analogue. Co-Ral has been the subject of toxicity studies in dogs and rats (unpublished data) which show that prolonged feeding at levels up to 100 mg./kg. of diet produces no pathologic changes in periods up to 60 days.

Measurement of the acute toxicity to female rats indicated that the LD_{50} is 2.6 mg./kg. by the intraperitoneal route and 8.0 mg./kg. when given orally. The oxygen analogue of Co-Ral is about one third as toxic as DFP and Mintacol, and approximately as toxic as TEPP (or HETP). No external signs of irritation or congestion were observed in rabbit eyes in which one drop was instilled three times a day for periods of one week. In human eyes, treatment extended over periods of five months, with no external evidence of irritation, or congestion on dosage of 0.25, 0.5 and 1.0 percent concentrations used three times a day.

Several other organic phosphates were studied and found to have either weak miotic effect or short duration of action. These included the insecticide Dipterex, which is water soluble and has a low oral toxicity in the range of 450 mg./kg. but had much shorter duration of miotic effect. Also studied were vinyl dipterex and Lilly no. 21315.

The effect of carbonic anhydrase inhibitors on urinary citrate excretion of humans, rats and

rabbits. Marguerite A. Constant, Ph.D., and Bernard Becker, M.D., Department of Ophthalmology, Washington University, Saint Louis.

Acetazolamide, (250 mg. q6h), methazolamide (100 mg. q8h) or dichlorophenamide (50 mg. q6h or 100 mg. q8h) were approximately equally effective in causing a marked decrease in urinary excretion of citrate by humans.

The incorporation of these drugs into the diet of rats at a level of 33 mg. percent, 6.5 or 13 mg. percent and 13 mg. percent, respectively, similarly resulted in a marked decrease in urinary citrate of this species.

However, in rabbits, the incorporation of 100 or 250 mg. percent of acetazolamide or 100 mg. percent of methazolamide into the diet failed to depress their urinary citrate excretion. The daily intraperitoneal injection of 750 mg./kg. of acetazolamide or of 150 mg./kg. of methazolamide in three divided doses was also ineffective in rabbits even when consuming a diet containing carbonic anhydrase inhibitors.

The effect of intraocular pressure on the resistance to outflow in the cat and rabbit. Mansour F. Armaly, M.D., Department of Ophthalmology, State University of Iowa, Iowa City, Iowa.

The facility of outflow was determined in the freshly enucleated eye by investigating the inflow rate into the anterior chamber required to maintain a certain pressure level constant. Pressure levels between 10 and 100 mm. Hg were investigated in sequence: starting at 10 or 20 mm. Hg and introducing step changes of 5, 10, or 20 mm. Hg rise at a time until the upper limit was reached. The procedure was then repeated by starting at the lower limit again; or having reached the upper limit, approach the lower limit in steps of similar magnitude.

In both species, the facility of outflow was less, the higher the intraocular pressure. This effect of intraocular pressure in reducing the facility of outflow was independent of the "washing effect" of Bárány and could not be explained by a "precipitate" in the filter. In six of the 41 eyes investigated, this phenomenon was elicited only after the step change in pressure was introduced via the posterior chamber.

A constant step change in pressure produced greater reduction in facility the lower the initial pressure at which it was introduced. Thus an exponential and not a linear function results. The magnitude of reduction in C values when the pressure was raised from 20—40 mm. Hg varied between 15 and 65 percent and had an average of 25 percent.

When the resistance of the trabecular meshwork was markedly reduced by hyaluronidase injection into the anterior chamber or by trabeculotomy, the facility imposed by the intrascleral passages had identical relationship with intraocular pressure level.

These results are consistant with a model that allows lateral compression and increase in volume to produce a reduction in the "effective pore size." These findings indicate that the facility of outflow enforced by the trabecular meshwork and by the intrascleral passages is not independent, but intimately linked with the physical characteristics of the eye: the intraocular pressure, intraocular volume, and the elasticity of the eyeball. Such a relationship markedly potentiates the ability of "vascular" or transient rises in intraocular pressure to produce a maintained rise.

Parasympathetics and the facility of outflow: Effect and mechanism. Mansour F. Armaly, M.D., Department of Ophthalmology, State University of Iowa, Iowa City, Iowa.

The intraocular pressure during maintained stimulation of the orbital parasympathetic pathway was lower than prestimulus pressure in 85 percent, equal to prestimulus pressure in 10 percent and higher than prestimulus pressure in five percent of the experiments.

The effect of parasympathetic stimulation on outflow facility was investigated in the anesthetized cat as well as in the enucleated eye: using the constant-pressure perfusion technique and the constant-rate perfusion technique, once a steady-state was established during nonstimulation or during maintained stimulation.

Parasympathetic stimulation produced marked increase in outflow facility in the anesthetized animal as well as in the enucleated eye which reached as high as 200 percent.

The increase in facility was greater, for greater stimulus intensity, until a maximum response was obtained.

The increase in facility for the same intensity became less the higher the experimental pressure used in the determination. When maximum responses were investigated for various pressure levels, the increase in facility during stimulation was greater the higher the intraocular pressure used for the determination.

The increase in facility during stimulation was independent of the pupil size before stimulation was started and of the magnitude of pupillary constriction during stimulation.

Fifteen microgrammes of atropine intravenously eliminated completely the effect of maintained stimulation on steady state intraocular pressure and on the outflow facility.

Pilocarpine and BC-48 produced similar effects on facility of outflow in the anesthetized animal as well as after enucleation. In effective concentration they eliminate the effect of stimulation on outflow facility.

Trabeculotomy eliminated the effect of stimulation and of parasympathomimetic drugs on outflow facility.

An increase in outflow facility was found even when the steady state pressure during maintained stimulation or after parasympathomimetic drugs was equal to or higher than prestimulation pres-

sure indicating that an increase in inflow rate must have accompanied enhancement of parasympathetic activity by electrical stimulation or pharmacologic agents.

It is concluded that parasympathetic stimulation and parasympathomimetic drugs produce an increase in facility of outflow and in inflow rate and that the increase in facility of outflow is achieved by their action on the ciliary muscle-trabecular meshwork apparatus and not via blood vessels or constriction of the pupil.

Effect of phenylephrine hydrochloride on the miotic-treated eye. Bernard Becker, M.D., Tracy Gage, M.D., Allan Kolker, M.D., and Andrew Gay, M.D., Department of Ophthalmology, Washington University School of Medicine, Saint Louis.

In a series of normal eyes the instillation of phospholine iodide 0.25 percent, demecarium bromide 0.25 percent, or Pilocarpine two percent resulted in an increase in outflow facility, a decrease of intraocular pressure, and intense miosis. The administration of phenylephrine HCl 10 percent to these normal eyes dilated the miotic pupils without altering the tension or outflow facility. In a series of eyes with chronic simple glaucoma controlled on demecarium bromide 0.25 percent, phenylephrine HCl dilated the pupils without changing tension or outflow facility.

HC-3: an ocular study of its mode of action and effect on intraocular pressure. R. D. Whinery, M.D., and M. F. Armaly, M.D., Department of Ophthalmology, University Hospitals, Iowa City, Iowa.

This is a preliminary study made with HC-3, one compound of a group of 11-bis-oniumbiphenyl derivitives prepared at the State University of Iowa in 1954.

Using unanesthetized cats and rabbits one and two-percent solutions of HC-3 in 1/1000 aqueous Zephiran were found to produce mydriasis and absence of the light reflex on the side in which the drops were given after 45-90 minutes. The mydriasis of HC-3 was counteracted by topically applied pilocarpine, neostigmine, physiostigmine, DFP, and Mecholyl. HC-3 had no effect following the topical administration of DFP, or Doryl, or Eserine, or Pilocarpine. It was felt that in the cat eye HC-3 may act by competing with cholinesterase inhibitors, or by the release of cholinesterase or the prolongation of its action.

The effect of topically applied HC-3 on frequent readings made with a Schiøtz tonometer was also studied. Ten cats anesthetized with intrapleural Nembutal were used. The opposite eye was used as a control. Three of the cats showed no difference in scale readings and died in less than four hours. Five cats showed a rise in scale reading in the eye receiving the HC-3. This occurred predominantly four hours or more after administration of the drug. Aqueous Zepharin alone produced no effect. One cat showed no change in scale reading in the eye receiving HC-3 while the fellow-eye showed a higher Schiøtz scale reading.

Further studies with HC-3 are being carried out using constant recording electronic pressure devices.

The distribution of C^{14} labeled atropine in the rabbit's eye. R. G. Janes, Ph.D. and J. F. Stiles, B.S., State University of Iowa College of Medicine, Iowa City, Iowa.

Atropine, labeled With C^{14} on the tropic acid moiety, and made up as a one-percent atropine sulfate solution was administered to the eyes of albino rabbits weighing two to three kg. One fourth ml. of this solution, which contained 0.48 μc. of radioactivity, was administered subconjunctivally to living and freshly killed animals and topically to living rabbits. It was apparent that atropine entered the eye by diffusion and a functioning circulatory system was not a prerequisite for this penetration. The C^{14} labeled material was found in all parts of the eye, even in the retina. More atropine entered the eye following topical instillation, provided the cornea was covered with the material, than when similar amounts were given subconjunctivally. Most of the C^{14} labeled material was present in the urine within five hours after it was given subconjunctivally to the living rabbits.

Low temperature crystallography of bovine vitreous. John A. Buesseler, M.D., Medical Center, University of Missouri, Columbia, Missouri, G. L. Rapatz, Ph.D., American Foundation for Biological Research, Madison, Wisconsin, Ronald L. Engerman, M.S., Department of Zoology, University of Wisconsin, Madison.

As a natural progression of previous work by one of us, G. L. Rapatz, with B. J. Luyet (Biodynamica, 7:346-354, 1957), this initial investigation of the pattern and type of ice formation in vitreous humor was instituted. The vitreous under study was prepared in a thin film (approximately 25 micra thick) by sealing a small droplet of the material between two cover glasses 70 micra thick. Rapid cooling was accomplished by sudden immersion of this mount in an alcohol or isopentane bath previously cooled to the specifically desired temperature in apparatus equipped for cinemicrography according to the methods of Rapatz and Luyet.

When fresh whole bovine vitreous at its normal concentration was used, we were able to obtain at −0.5°C. and −0.7°C. various hexagonal crystallization centers with typically three main axes. The centers at the high temperature were smooth and did not show the marked dendritic branching of those produced at −0.7°C. In structure, these crystalline patterns were very

similar to those obtained with dilute albumin, glycerol, and polyvinylpyrolidine. At these temperatures and concentration, seeding was necessary to induce crystallization. When such vitreous humor specimens were cooled very rapidly by being plunged into an isopentane bath of from −70°C. to −160°C. the freezing of the vitreous was accomplished by irregular dendritic growth so transparent in character that it was best visualized in polarized light.

With specimens of bovine vitreous concentrated by freeze drying methods to obtain an 85 percent reduction by weight through removal of water, typical hexagonal crystalline structures were obtained at −12.5° and −15°. At temperatures of −40°C. to −90°C., plain spherulite crystallization centers were produced. Evanescent spherulites resulted from freezing at −150° and were not visible under ordinary light; however, under polarized light, a "maltese cross" shading effect was noted in the structures thus indicating the presence of minute needles of ice radiating from a central point in the structures. This latter specimen when warmed to a temperature of −65°C. recrystallized into an entirely different crystalline pattern within the same structural outline and was observable with ordinary light. In general, the freezing properties of concentrated bovine vitreous were remarkably similar to those of a glycerol solution of approximately three molar concentration and were unlike those of gelatin solutions as previously studied by Luyet and Rapatz.

On the relevance of interference microscopy in a study of the behavior of the vitreous humor of the eye. Arlene Crosby Longwell, Ph.D., Division of Biological and Medical Research, Argonne National Laboratory, Lemont, Illinois.

With the hope that interferometry, a new form of microscopy in biology, would yield some new information on the microscopic anatomy and certain physical properties of the vitreous, a preliminary survey was made on the fresh unfixed, unstained vitreous. The eyes from one-month-old, four-month-old and two-year and 10-month-old chickens, one-month-old and 17-year-old dogs, and a 72-year-old human were used. Observations were made with the A. O. Baker interference microscope. Pieces of the vitreous were dissected from the eye, placed without further treatment on a microscope slide and examined. Kodachrome photomicrographs were made to record color and intensity patterns.

A thin transparent hyaline-like membrane was detected around the vitreous of the chicken, dog and human. Similar-appearing bundles of fibrils were observed to be either loosely or well-associated into membranous-like sheets in both the chicken and dog. The fibrous bundles measured about 2.5 microns and 11.0 microns in width, and retarded 5460 × 10^{-8} cm. green light 0.23 and 0.13 wavelengths respectively in the chicken.

The secondary vitreous humor of the human eye showed numerous strands of loosely associated fibrils which appeared somewhat granular, probably due to the presence of cross striations. The fibrils travel together for some distance, then separate from one another. At points of close association these fibers retard green light 0.08 wavelengths, and, where they fray out, 0.02 wavelengths. More closely associated fibrous bundles were also observed which showed some evidence of a periodicity, and retarded the light 0.08 wavelengths. Finally a very smooth type of fiber was noted, its fibrillar nature detectable only where the ends of the fibers were frayed out. These smooth fibrous bundles have optical path differences somewhat higher than the others, from 0.10 to 0.17 wavelengths. The various fiber types range in width from about 3.0 to 20 microns.

These observations point out the usefulness of a new microscopic technique in application to an anatomic problem of long standing. Although dissection must partly alter and disorganize the structure of the vitreal network a critical and comparative study of such preparations should make it possible to determine to some extent the morphological characteristics of the fibrous component in normal eyes and in certain pathologic conditions. Also it is possible to determine optical path, refractive index and dry mass of the vitreal structures observed under the microscope.

Flat preparation of the rat retina stained with PAS. Ronald L. Engerman, M.S., John A. Buesseler, M.D., and Roland K. Meyer, Ph.D., Department of Zoology, University of Wisconsin, Madison, Wisconsin.

The method which Friedenwald and Becker developed for studying the vasculature in flat mounts of retinas by staining with a periodic acid—Schiff reaction has been reported by others to be non-applicable to the rat retina. The following is a procedure whereby rat retinas may be satisfactorily stained by this reaction and mounted flat for examination of the blood vessels. Immediately after enucleation the intact eye is fixed in Heidenhain's "Susa" fluid for 20 hours, washed in 70-percent ethanol, washed in 70-percent ethanol containing about 0.3-percent iodine until added iodine is no longer decolorized, and washed again in fresh 70-percent ethanol. In this medium the eye is opened coronally and the retina dissected out. After hydrating the retina through an ethanol series to water, residual iodine is removed by a two-minute bath in five-percent thiosulfate and the retina is washed in four changes of water. Subsequently, the retina is immersed in the Hotchkiss reagents quoted by Friedenwald (Am. J. Ophth., 32:487-498, 1949): aqueous periodic acid (for 20 minutes), transferred through water and 35-percent ethanol to the reducing rinse (20 minutes), transferred through 35-percent ethanol and water to fuchsin-sulfite (20 minutes), washed in three 10-minute changes

of sulfite water, washed in water, and partially dehydrated in 35-percent, 50-percent, and 70-percent ethanol. While immersed in 70-percent ethanol the retina is incised radially to permit it to flatten, and dehydration is then completed in two changes each of 95-percent and absolute ethanol, followed by clearing in xylol and mounting with the nerve fiber layer up in piccolyte resin. Since fresh reducing rinse blocks subsequent coloration of the vessels, the reducing rinse we use is one to three days old. Vessels of the iris are better stained by substituting four 10-minute washes in water for the reducing rinse. Immature vessels of the developing rat retina were less well delineated than vessels of the mature retina, but the method has been usable also for staining vessels in flat mounts of adult rabbit and mouse retinas, as well as the few vessels of the guinea pig retina.

Iridopathy and retinopathy produced by deoxycorticosterone acetate in the rat. Ronald L. Engerman, M.S., John A. Buesseler, M.D., and Roland K. Meyer, Ph.D., Department of Zoology, University of Wisconsin, Madison, Wisconsin.

Previous studies have demonstrated that the administration of deoxycorticosterone acetate (DCA) can elicit vascular hypertension and arteriolar hyalinization in the rat, and that these effects are intensified in unilaterally nephrectomized rats given 0.9-percent sodium chloride as drinking water. Robert has reported (Experientia, 13:457, 1957) that in rats so treated, lesions occurred in the anterior segment of the eye, but retinal changes appeared infrequent and consisted of a slight arteriolar hyalinization.

The following study was conducted to evaluate further the effects of DCA-hypertension on the iris and retina. On the initial day of the experimental period, 35 male Holtzman rats of mean weight 120 gm. were unilaterally nephrectomized and their drinking water was replaced with a 0.9-percent solution of sodium chloride.

Thirty of these rats were injected daily thereafter with 3.0 mg. of DCA microcrystals suspended in a saline solution of carboxymethyl cellulose and Tween 80 with a preservative of benzyl alcohol. (In a pilot survey this treatment produced systolic blood pressures above 200 mm. Hg within four weeks.) The remaining five rats were injected daily with a placebo consisting of the suspending medium alone.

Ten additional rats of the same age were studied as intact, untreated controls. Irises and retinas of placebo-treated rats were found to be indistinguishable from those of the normal rats. By comparison with these groups, iridopathy and retinopathy were observed during and after the third week of treatment with DCA.

DCA produced in the iris a grossly visible, persistent contracture line which appeared as a fibrosed blood vessel when examined with a slit-lamp biomicroscope, and which histologically consisted of a necrotizing arteriolitis. By the end of the fourth week, of the 30 rats injected with DCA 11 (37-percent) had exhibited this lesion and 13 (43-percent) had died. Additional lesions produced by DCA included hemorrhages and hemorrhagic cysts of the iris, as well as anterior and posterior synechias.

At the end of four weeks all rats were killed with ether and the enucleated eyes were fixed immediately in Heidenhain's "Susa" fluid. After fixation and washing, eyes from DCA-treated rats exhibited a supranormal volume of Schiff-positive proteinaceous coagulum in the vitreous chamber. Retinas were dissected from the eyes and mounted flat for examination after staining with the periodic acid—Schiff reaction. Stained paraffin sections of a few retinas were also examined.

Retinopathy was frequently produced by DCA, and consisted of arteriolar hyalinization near the optic disc, exudates, retinal detachments, vertical retinal folds, and cystoid degeneration. Accompanying these abnormalities were raspberry-shaped aggregates of intracellular Schiff-positive globules, resembling Russell bodies, and varying in diameter up to about 15 micra. These aggregates were most frequently observed in the inner retinal layers, although they occurred elsewhere in the retina commonly among exudates. Less frequently observed were distinct arteriolar compression of a venule and segmental arteriolar constriction.

The use of succinylcholine in ocular anesthesia. William M. Lewallen, Jr., M.D., and B. L. Hicks, M.D., Pueblo, Colorado.

Succinylcholine, a relatively new short-acting skeletal muscle relaxant, has become very popular because of its many advantages over the longer acting relaxants such as curare. It has been reported to cause increased intraocular pressure and other deleterious side effects because of contracture of the extraocular muscles, making it undesirable in ocular cases.

Ocular tensions were checked on a series of 82 general surgical cases after being induced with sodium pentothal and well oxygenated. Tension was checked after succinylcholine was given and no significant rise was recorded. Tension was checked at two-minute intervals for a period of seven minutes following intubation. Intraocular pressure rose in almost every case following intubation but returned to initial levels or lower within five to seven minutes.

A series of 13 cataract cases was done under general anesthesia utilizing succinylcholine for intubation and also an intravenous drip of succinylcholine. Tension changes paralleled those of the general surgical cases. Retrobulbar injection seemed further to lower the pressure although in three cases where retrobulbar injections were administered prior to giving succinylcholine for intubation there was still a rise

in pressure following intubation.

The increases in intraocular pressure observed in this series are felt to be due to increased intrathoracic pressure with pressure on the great veins and subsequent damming of the venous flow out of the eye and orbit.

In none of the cases of this series was any enophthalmos or rotation of the globe observed which could be attributed to a contracture of the extraocular muscles.

Succinylcholine has a different method of action from curare and does not appear to be selective in its onset as is curare. It should not be used in any conscious patient but it would appear safe when used as an adjunct to general anesthesia for ocular surgery including intraocular cases.

Mechanism of immediate parasympathetic effect of intraocular pressure. Mansour F. Armaly, M.D., Department of Ophthalmology, State University of Iowa, Iowa City, Iowa.

The immediate intraocular pressure response to brief electric stimulation of the orbital parasympathetic pathway in the cat was investigated in the enucleated eye and in the intact anesthetized animal.

In the enucleated eye the response is a rise in pressure of 1.0 to 3.0 mm. Hg; for a given intensity, increasing the intraocular pressure level reduces the magnitude of the response. In the anesthetized cat the response is a reduction in pressure.

The objective of the study was to separate these two simultaneously occurring components in the anesthetized cat by varying stimulus intensity, intraocular pressure, and systemic arterial and venous pressure.

When the response is obtained at varying intraocular pressure levels ranging between 5.0 to 150 mm. Hg, the response undergoes the following changes in quality and quantity: a rise in pressure of 1.0 to 2.0 mm. Hg for intraocular pressure lower than 8.0 mm. Hg; a rise followed by a reduction equal in magnitude for intraocular pressures between 8.0 to 10 mm. Hg; no noticeable response at a pressure of 10 mm. Hg and a reduction in pressure for levels greater than 10 mm. Hg that increases in magnitude as the intraocular pressure is increased and reaches a maximum after which the reduction becomes less for higher intraocular pressure levels until it becomes zero and reverses to a rise when the intraocular pressure approaches the systemic arterial systolic pressure.

When the magnitude of response is plotted against intraocular pressure, a symmetrical parabolic curve is generated which intersects the x-axis at 8.0 to 10 mm. Hg and at a level equal to systolic pressure; the position of the peak was related to average systolic pressure and occurred when the intraocular pressure level was equal to 0.6 to 0.7 of the average systemic blood pressure.

Increasing intensity, markedly increased the magnitude of the response until a maximum was reached. Variation in intensity did not alter the shape of the curve, the position of the peak or the intersection with the x-axis.

The pressure response was found to be identical with the intraocular volume response indicating that a change in elasticity was not responsible for the characteristics of the pressure response curve.

This demonstrates that the immediate intraocular response to parasympathetic stimulation is the resultant of two simultaneously occurring events: a muscular one producing a rise and a vascular one producing a reduction.

A clinical study of the consistency of 1955 calibration for various tonometer weights. Mansour F. Armaly, M.D., Department of Ophthalmology, State University of Iowa, Iowa City, Iowa.

If tonometry were performed on the same eye using the three tonometer weights, would the estimates of intraocular pressure obtained from the 1955 calibration tables be identical for the three weights?

Using the 5.5 gm. weight, tonometry was performed on one eye and then on the second eye; the 7.5 gm. weight was then placed and tonometry repeated on the first, then on the second eye. The 10 gm. weight was used in the same sequence. This was followed by another tonometry with the 5.5 gm. weight in the same sequence to evaluate the effect of repetition and provide a correction factor to estimate what the pressures would be at the various steps in the procedure were they independent of "massage." By considering the total reduction fractionable by the ratio of the various weights used.

Five hundred subjects with normal eyes and central visual fields and with ages varying between 15 and 95 years were subjected only once to this test. Only readings that fell between scale readings of 3.0 and 10 were considered in this study.

The mean of the 5.5 gm. reading was significantly less than that of the 7.5 gm. weight and this, in turn, was significantly less than that of the 10 gm. weight despite the fact that successive tonometries should yield lower estimates of pressure. The fourth 5.5 gm. weight reading was significantly lower than the initial 5.5 gm. weight. When the effect of repetition is corrected for, the discrepancy between means obtained by various weights becomes greater.

When the differences between 7.5 and 5.5 gm. weight readings and those between the 10 and 5.5 gm. weight were averaged for various pressure levels, the discrepancy was uniform for pressures between 15 and 25 mm. Hg, but was significantly less for pressure readings between 10 to 14 mm. Hg. This nonuniformity is best referred to a nonuniformity in the calibration "error."

When these differences were averaged for each age group, a parabolic distribution of differences vs. age resulted. This reached a peak at 40 to 45 years. This cannot reflect a discrepancy in the calibration, but the distribution of a biologic variable influencing this difference, namely, the coefficient of ocular rigidity. This states that this coefficient increases with age, reaches a maximum at 40 to 50 years and becomes less after that.

When the differences were investigated in males and females, the mean values in the females were markedly and significantly higher than those in the males. This again is interpreted as reflecting the comparison of ocular rigidity in the two sexes.

All these relationships were identical for differences between 5.5 and 7.5 gm. weights and those between 5.5 and 10, in raw scores and in those corrected for the effect of reduction.

Fifty tests were performed by using the 5.5 gm. weight in all trials instead of the various tonometer weights. A significant reduction became apparent after the first tonometry. This exposes another source of "error" in tonography, for it should be significant whether P_o in tonography is read from the beginning of the tonogram or from the initial tonometry. The former procedure underestimates C values. This effect is more in the normal eye than in the glaucomas, thus it increases the overlap of the two populations.

Ophthalmic Miniature

January 1st, 1708, a Priest about 60 years old, who was operated on for a cataract, by Mr. Gerald, an eminent oculist, and which had afterwards passed between the Uvea and Cornea, I extracted in the following manner, in the presence of M. Mery, Surgeon of L'Hotel Dieu, M. Remy, sworn Surgeon, and Brother Charles St. Yves. (This was the noted Oculist.) I pierced the inferior and external part of the Cornea, with a fine Needle; and being entered, into the anterior Chamber of the Eye, I pushed it on, 'till it again passed thro' the other side of the Cornea, that is to say, thro' that part, next the internal Angle of the Eye: Then by means of a Groove in my Needle, I introduced the point of a Lancet, and so opened the Cornea, from one puncture to the other, and with a fine Hook, drew forth, the opaque body. The Patient soon recovered, and can see large objects, without Glasses, and real small print, by the help of Spectacles.

"A Critical Analysis of the New Operation for a Cataract,"
Mr. O'Halloran of Limerick, 1750.

SOCIETY PROCEEDINGS

Edited by DONALD J. LYLE, M.D.

NEW ENGLAND OPHTHALMOLOGICAL SOCIETY

443rd Meeting, April 16, 1958

VIRGIL G. CASTEN, M.D., *presiding*

APPLICATION OF EMBRYOLOGY TO CLINICAL OPHTHALMOLOGY: THE HOWE LECTURE.

IDA MANN, D.Sc., Perth, Western Australia: The early experimental embryologists established first the principle that interference of any sort with a developing embryo will produce an abnormality of structure which tends to be specific for the stage of development at the time of application of the noxa, rather than for the nature of the latter. Then arose the concept of existence on the one hand of a group of abnormalities whose occurrence was genetically determined: the hereditary and familial conditions—the genotypes—and, on the other, of a group of clinically very similar anomalies of structure—the phenocopies—determined by the occurrence of a fortuitous noxious influence at the stage of development at which the corresponding genotype would have begun to manifest itself.

These early investigators used methods of interference that can be classified as mechanical, thermal, chemical, and electro-magnetic. Through experiment along these lines we have become familiar with the effect of causing arrests and aberrations of growth at various stages of normal development. This experimental work continues to produce results, sometimes of great value, as in the case of Ashton's experimental work with oxygen in the elucidation of retrolental fibroplasia.

Every abnormal incident in the development of an embryo can be classified in two ways, either by the nature of the happening or the time at which it took place. Classification by time of interference is of more practical use because by its means we can understand the relationship which the phenocopies so often bear to the genotype in the cases where a congenital anomaly arises in connection with maternal illness. The recognition of this mechanism has been well shown in the work of the Australian team headed by Gregg on the effect of maternal rubella on the embryo. Much work is still required on this aspect.

The abnormalities that are met with in practice can be classified as follows:

1. Genetic: (a) affecting prenatal development; (b) affecting postnatal development; (c) affecting adult maintenance of function.

2. Genetically determined but environmentally produced.

3. Environmental: (a) infection of the mother; (b) dietary imperfections of the mother: deficiency of vitamins, deficiency of trace elements, excess of trace elements, uterine hemorrhage, endocrine disorders in the mother, prematurity.

4. Sporadic: cases in which neither the family history nor the pregnancy history contains anything relevant.

With these facts in mind we must now decide whether the co-operation of clinical medicine with the experimental pathologists, embryologists, and geneticists has been worth while. The answer is obvious. If only two of the many discoveries of the last 50 years had been made, namely, the relationship of rubella during the second month to cataract, deafness, and heart disease, and the role of oxygen in retrolental fibroplasia, clinical medicine would still be the gainer. It now remains by painstaking investigation of pedigrees, of pregnancy illnesses, of dietary and of environment factors, to amass more knowledge and to observe more correlations.

To our previous concepts of environmental hazards is now added another, possibly the greatest importance of all, namely, exposure

to ionizing radiations. That the experiment takes so long to produce its effect is deplorable since much damage may be done before it is even suspected, but we already have a pointer in the connection between leukemia and exposure in embryonic life. It remains for the scientists of the future to assess the ultimate racial effects.

The only way we can build up our concept of causation and possible elimination of eye abnormalities is to proceed with research along three lines: (1) the study of normal development; (2) the study of genetics; and (3) the study of experimentally induced abnormalities. To this laboratory work must be added the clinicians' contributions of descriptive teratology, study of pedigrees, and inquiry into pregnancy histories.

Clinical experience with a new miotic: Phospholine iodide

R. C. Lawlor, M.D., and Pei-Fei Lee, M.D., Boston: Phospholine iodide is an extremely potent long-acting anticholinesterase. A brief clinical trial with this drug was attempted with 35 glaucomatous eyes. It was found to lower intraocular pressure, improve aqueous outflow, and control ocular tension in 19 out of 23 eyes where other miotics, including DFP and acetazolamide, had failed.

The drug was found to be effective in controlling intraocular pressure in glaucoma associated with aphakia, but no more satisfactory than with glaucoma in nonaphakic eyes.

Phospholine iodide has the advantage over other miotics of requiring only one instillation a day for maximum effect.

No definite conclusions can be drawn in regard to the relative effects of Phospholine iodide on eyes with various types of glaucoma. The results were generally the same in the three types present in this study: Open-angle, chronic angle-closure, and secondary (lens extraction).

This drug is not the ideal miotic. It was found to produce side-effects, much the same as those ascribed to DFP. Most of these reactions lasted but a few days. The blurring, noted in a few cases, was probably due to pseudomyopia. Since it was most marked for a few hours after each instillation, it was suggested that the drug be given at bedtime. Marked miosis was observed when the 0.25-percent concentration was used. This produced severe visual impairment in one patient with bilateral disciform degeneration; 0.0125-percent solutions produced less miosis. Other side-effects were browache, ocular pain, and congestion of the globe. There were no systemic effects, as well as no case of retinal detachment or iris cyst. No sensitivity to the drug was noted.

Reports have indicated that this drug was stable indefinitely when kept at 5°C. Our observations suggested somewhat different conclusions. Its effect in lowering intraocular pressure was found clinically to diminish in six weeks despite refrigeration between instillations.

Charles Snyder,
Recorder.

MEMPHIS EYE, EAR, NOSE, AND THROAT SOCIETY

Mucocele of left frontal sinus

Huey M. Porter, M.D., reported the case of a 26-year-old Negro who was referred to the out-patient clinic of the Memphis Eye, Ear, Nose, and Throat Hospital on May 3, 1958, after having been seen three days earlier by a local physician.

The chief complaint of this patient was that he had noticed a swelling above his left eye for the past year and recently had had frequent headaches. The referring physician had aspirated some fluid from this swelling three days prior to the patient's visit to the out-patient clinic.

The present illness began one year prior to his visit, at which time he began to notice a "swelling" above the left eye and to the left of the bridge of the nose. The size of the

"swelling" had progressively enlarged until the time of admission. For the past few weeks he had noticed frequent headaches and his left eye seemed to "stick-out." He had also noticed occasional double vision for the past few weeks.

The past history and family history revealed nothing of any significance.

The physical findings of note were limited to the head and neck region. There was a marked exophthalmos of the left eye, with the eye being outward and downward. There was a soft swelling in the left supraorbital and medial canthus regions. These areas were nontender and soft. The pupils were equal and reacted to light and accommodation. The vision was 20/20 in the right eye and 20/30 in the left eye. The temperature was 98.6 mm. Hg. The nasal cavities presented no abnormalities.

Roentgenograms of the frontal sinuses revealed generalized cloudiness of the left frontal sinus region and an enlargement of the sinus cavity, with absence of the partition separating the left and right frontal sinus cavities.

On May 11, 1958, this patient had surgery under local anesthesia. A modified Killian incision was employed and a large cystic cavity, which was filled with "bile" colored fluid, was encountered. With the aid of an additional incision about one inch above the medial portion of the left brow and a burr hole in the frontal bone, the cyst lining was removed in its entirety. The cyst had almost completely eroded the medial orbital wall and the floor and the roof of the frontal sinus. The cyst lining and the dura were adherent in many areas superiorly and during the surgical dissection the dura was perforated several times. The optic nerve and vessels were noticed to be pushed outward and downward and care was taken to avoid injuring these structures. The ethmoid and sphenoid cells were almost obliterated by the cyst and the remnants were exenterated surgically. The cyst had only "herniated" through to the opposite frontal sinus and this portion was easily removed. An opening was made in the superior lateral nasal wall and the surgical defect was packed with vasoline gauze and brought out through the left nares. The wound was closed in the usual manner.

The pathologic report was "Fibrous tissue with chronic inflammation and hemosiderosis consistent with mucocele."

Postoperatively the patient was given large doses of antibiotics and the postoperative course was uneventful except on the night following surgery when he had a generalized clonic convulsion, which required barbiturate injections.

The patient was discharged on the seventh postoperative day and was instructed to return to the clinic in three days for follow-up. Unfortunately, he failed to return.

Late infection after trephination

Philip Meriwether Lewis, M.D., reported a case of purulent endophthalmitis eight years after a trephining operation. Mrs. C. G., a white woman, was aged 72 years when first seen in July, 1948, with an acute attack of glaucoma in her left eye of two days' duration. There was a dilated, fixed pupil, steamy cornea, and tension of 65 mm. Hg (Schiøtz). Vision was 10/200. Frequent treatment with strong miotics had little effect so on the following day an iridectomy was performed. The right eye was found to be totally blind with absolute glaucoma and a tension of 60 mm. Hg, but no pain. She stated that the right eye had been blind for two years but that she had never had any previous trouble with the left eye.

Following the iridectomy and during the patient's hospital stay, the tension in the left eye was 15 mm. Hg. It soon rose into the high 30's and occasionally was 40 mm. Hg or more in spite of the regular use of miotics. On October 15, 1948, a trephining operation (1.5 mm.) was done at the 6-o'clock position on the limbus. The conjunctival flap was buttonholed during the operation but was satisfactorily repaired at the time. Convalescence was uneventful. There was a good filtra-

tion bleb and vision was 20/50, J3 close (early cataract). The tension ranged between 15 to 18 mm. Hg.

In 1949, the right eye became very painful and highly inflamed. Enucleation with a plastic ball implant was performed. The left eye continued to filter well, and useful vision was maintained until November 23, 1956, when her eyes became red and the lids were sticky with secretions. Two days later she noticed that she could not see and was then brought in for examination.

The eye was highly inflamed, with a purulent exudate extending from the conjunctiva through the trephination opening. The anterior chamber was almost filled with yellow exudate. Cultures were taken immediately but revealed no organisms. Treatment consisted of full doses of Chloromycetin, triple sulfonamides, and foreign-protein injections. The anterior chamber was irrigated with penicillin and frequent applications of antibiotics were made. After five days, it was evident that the battle was hopeless and the eye was eviscerated. Subsequently, it was learned that the patient had become very careless and forgetful in her old age and had not been using the prescribed antiseptic drops (zinc sulfate) for several months prior to the infection. Perhaps a more potent antiseptic drop or ointment should be used after filtering operations and the importance of frequent instillation be emphasized to patients and their families.

Thrombosis of Inferior Temporal Branch of Left Retinal Artery

Alice R. Deutsch, M.D., presented Mr. A. O., a 60-year-old tailor. He was seen at the office on February 9, 1955, with the history of spells of blurred vision of the left eye for the last two days. About 30 minutes before rushing to the office he had a similar spell. He closed his eyes for several minutes as he had during the previous attacks but when he opened his eyes again he noticed that he could not see at all with the left eye.

On examination the right eye was found to be normal externally; some opacities were visible in the posterior cortex of the lens; the disc had a normal color and the margins were sharp; the fundus picture was classified as arteriolosclerosis Grade II to III. His corrected vision equalled 20/30 and J3. The left eye showed marginal corneal opacities. The pupil was dilated and did not react either directly on consensually to light. The retina showed a diffuse glassy edema and the disc was pale and was not very sharply outlined. The arteries were narrow and difficult to see; the veins were very dark but did not show any breaking up of the blood stream. Vision was only light perception in the temporal field; tension equalled: O.D., 17.3 mm. Hg; O.S., 22.1 mm. Hg. His blood pressure was 210/120 mm. Hg.

Mr. O. gave the information that he was supposed to take some medicine for his blood pressure but that he did not take it regularly. His family physician could not be reached by telephone for consultation. Because of the presence of the severe vascular fundus changes the diagnosis of thrombosis of the retinal artery was made in preference to an embolism.

It was thought essential to relieve a possible simultaneous vascular spasm before irrevocable damage to the retina should take place. Nicotinic acid (100 mg.) was injected slowly, intravenously. In spite of the fact that Mr. O. got very flushed and the blood pressure dropped from 210/120 to 180/110 mm. Hg, no change could be seen in the retina of either eye. It was decided at this time to give Mr. O. a retrobulbar injection of three cc. of two-percent procaine and at the same time give 0.12 g. papaverine hydrochloride intravenously by slow injection, while the blood pressure was checked every minute. There was no remarkable drop in blood pressure.

When the patch was removed from the left eye, the patient at once noticed that he could see again. The pupil retcted sluggishly to light and was much narrower than before but still more dilated than in the other eye.

The retinal edema, however, was unchanged but the upper branches of the retinal artery were visible. Later on Mr. O. was admitted to the hospital and, after consultation with his family physician, was put on Serpasil (0.10 mg.), Apresoline (25 mg., three times daily), Nitranitol (32 mg. three times daily) and Dicumarol (200 mg. on the first day and 100 mg. the second day). The dosage of the antihypertensive, vasodilator, and anticoagulant drugs were adjusted from day to day.

The fundus picture showed remarkable changes. On the evening of the first hospital day, the edema in the upper half of the fundus had receded. The edema in the lower half of the fundus got more pronounced and appeared milky the next day. After one week, the nasal inferior fundus periphery was clearer while the temporal inferior fundus showed a peculiar striated appearance with many flame-shaped hemorrhages; the inferior temporal artery had a clublike dilatation on the corresponding disc margin and ended in a grayish white oblong streak which got abruptly thinner until it tapered off toward the periphery.

Mr. O. stayed in the hospital for two weeks. He was kept under Serpasil (0.1 mg., three times a day) and Dicumarol (50 mg.) by his family physician. The Dicumarol was discontinued after six weeks. He was seen again on May 11, 1955. At this time the right eye was unchanged. The disc of the left eye was dimly outlined and paler than the right, especially in the lower half. The inferior temporal branch of the retinal artery was transformed into a white cord. There were some cork screw veins visible in the same quadrant. The other branches of the retinal artery were narrow, with increase in the light reflex and considerable sheathing; there was a tapering, banking, and deflection of the veins at the arteriovenous crossing. His corrected vision equalled 20/40 and J3. He had a sector-shaped defect in the visual field nasal and above.

The effectiveness of vasodilating drugs has been open to considerable doubt in spite of the fact that these drugs were used to treat conditions supposedly caused by diminished blood supply. In many instances these drugs are without any effect, in other instances they may actually decrease the intraocular blood volume, secondary to dilatation of the peripheral vascular bed. Peripheral-acting drugs, depressing the smooth vascular muscles, like nicotinic acid, were found to have no effect on the intraocular blood volume except when they are given by retrobulbar injection. Retrobulbar procaine was found to increase the intraocular blood volume only when given in large doses. The effect might be secondary and caused by local irritation.

This case was presented for two reasons:

1. It is very rare that a patient has the understanding that he is in a state of emergency, and only few cases are seen so early after an intraocular vascular catastrophy.

2. To evaluate the effectiveness of the treatment applied and the cause for the relaxation of the vascular spasm. Papaverin acts directly on the smooth vascular muscles, predominantly on the arteries of the brain and on the coronary arteries, and supposedly has no effect on the intraocular blood volume. The same is true for comparatively small doses of retrobulbar procaine. However, experimental studies and corresponding results do not preclude that under certain abnormal conditions, such as retinal spasm, changes in retinal blood flow might occur, stimulated by adequate drugs.

Hyaline bodies of optic disc

Alice R. Deutsch, M.D., presented C. K., a 37-year-old Negro truck driver. He was seen for the first time in 1951 when he came to have his lenses replaced. No abnormalities were visible in the position, motility, or anterior segments of either eye. The media were clear; the discs were grayish, the physiologic cuppings were veiled, and many hyaline bodies were visible, especially over the superior half of the discs. The arteries and veins on the discs were heavily sheathed.

His corrected vision was: O.D., −1.0D. cyl. ax. 180°; O.S., −0.5D. sph. ⊃ −1.0D. cyl. ax. 165° was 20/20 and J1 in each eye. The tangent-screen showed a mild enlargement of the blindspot (target 2/1,000). The peripheral fields were not taken. The history was not contributory.

He was seen again in 1954. There was apparently no change in the appearance of either disc. The corrected vision (correction unchanged) equalled 20/20 and J1. On the tangent screen a large arcuate scotoma was traced from the right eye and an enlarged blindspot was found in the left eye. Physical examination, including X-ray studies of the skull and neurologic consultation, was negative. His history and family history were reviewed with emphasis on possible isolated signs and symptoms of tuberous sclerosis but nothing was detected.

He was not seen again until the fall of 1957. At this time he complained for the first time of disturbance of vision, mostly when doing close work. There apparently was no change in the appearance of the discs and he saw 20/20 and J1 with the same correction, but there was an appalling loss of visual fields, consisting of a large nerve-fiber scotoma, breaking through the periphery, with a pronounced loss of field below for the right eye and nasal and below for the left eye.

Hyaline bodies of the disc have been the subject of several papers during the last few years. It has been demonstrated that the aspects of hyaline bodies might remain unchanged; that they might increase in size or become calcified; that they might be associated with defects in the fields, either in form of enlargement of the blindspot, arcuate scotomas, or contractions of the peripheral field, especially from below.

In one of the latest surveys, published by R. K. Lausche of the Mayo Foundation in 1957, 14 cases were reviewed. Six patients showed a progressive field loss. In six others the initial field loss remained stationary; and two patients had normal fields.

My second case is that of Mrs. J. M., aged 20 years. She was seen for the first time early in April, 1958. She complained of excruciating headaches which started a few weeks previously. She was in the fourth month of her first pregnancy, had always been healthy, and had had no disturbances with her pregnancy. She wore a mild myopic correction with which she saw 20/16 and J1. The only abnormal finding was the appearance of both discs. The discs appeared prominent and full and the physiologic cupping was absent. The veins were tortuous but not congested. Using indirect illumination, a marbling of the nervehead was seen. With the Hruby lens many yellowish-gray refractile bodies were visible, embedded deep in the disc tissue. There was no defect in the central or peripheral fields.

After consultation with her family physician and mentioning the possibility of a congenital anomaly of the discs, it was decided to restrict the examination to a neurologic survey and X-ray studies of the skull, both of which were negative. The headaches suddenly stopped about two weeks later. She was seen again on May 2, 1958. There was no change in the appearance of the disc. The family history gave no clues which could be associated with tuberous sclerosis. She was advised to remain under observation.

These cases are presented for two reasons:

1. To call attention to the guarded prognosis concerning the preservation of normal fields in the presence of hyaline bodies of the disc.

2. To demonstrate that deeply embedded hyaline bodies can simulate the appearance of papilledema, and that the differential diagnosis might occasionally prove quite difficult.

Eugene A. Vaccaro,
Secretary Eye Section.

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AMERICAN COLLEGE OF SURGEONS MEETING

MONTREAL, P.Q.

The American College of Surgeons, North Eastern Division, met in Montreal, P.Q., at the Queen Elizabeth Hotel and the teaching hospitals of McGill University, on April 6, 7, 8 and 9, 1959.

The Section of Ophthalmology was well attended, owing no doubt to a splendid program, the attraction of the new Queen Elizabeth Hotel, which is ideally designed for conventions, and to the fact that the teaching hospitals of McGill University in their newly renovated form were on view for the first time to outside ophthalmologists. These hospitals are the Montreal General Hospital, housed in a completely new building, the Royal Victoria Hospital and the Montreal Children's Hospital which are very largely new.

These attractions brought more than 300 ophthalmologists from the North-Eastern region of the continent to an enthusiastically attended three-day meeting. The general format was the same for each day. In the morning of each day formal scientific presentations and a symposium were presented. All joined for lunch and during coffee, questions from the audience were presented on the morning's topics for answering by the speakers. In the afternoon, all those attending were transported in buses to the Royal Victoria Hospital on the first day, to the Montreal General Hospital on the second, and to the Montreal Children's Hospital on the last.

In spite of this heavy scientific schedule, the social aspects were not forgotten. Montreal has many attractions for the convention visitor. Besides these, on Monday evening, April 6th, the members were entertained at a dinner at the Cercle Universitaire by the Montreal Ophthalmological Society. Dr. Lloyd G. Stevenson, Dean of Medicine at McGill, gave a delightful address. Tuesday evening, April 7th, was given over to private entertainment, and the annual dinner of the college was held on Wednesday evening, April 8th. At this dinner, Prof. Hugh MacLennan, the well-known Canadian novelist, gave an excellent address. Also there was the first Canadian showing of the new film entitled "The Hands We Trust."

The scientific program was excellent, being full of interesting material presented by outstanding speakers. The meeting opened on Monday, April 6th, with Dr. M. R. Marshall of Edmonton in the chair. The first paper was by Dr. Roland Cloutier of Montreal, on "Cataract extraction with the use of alpha-chymo-trypsin." In this paper, the author discussed his experience with this drug in 18 successful intracapsular cataract extractions.

Dr. A. G. DeVoe of New York presented a paper on "Ophthalmic injuries." He confined his remarks to injuries of the lid involving evulsions, lacerations and burns, and perforations of the globe. He emphasized the use of the halving operation for lacerations and the early repair of the globe, even though it might look hopeless. Enucleation was delayed for 10 days.

Dr. A. J. Elliot of Toronto, presented a most interesting paper on "The differential diagnosis and treatment of vitreous hemorrhage." Dr. Elliot presented a study of 57 cases of Eales' disease, discussing the differential diagnosis and its successful treatment with corticoids. These were usually given subconjunctivally. Antibiotic therapy was not found useful.

This was followed by a symposium on "Plastic surgery of the eye," under the leadership of Dr. A. G. DeVoe. Dr. Albert D. Ruedemann of Detroit discussed the importance of obtaining a good cosmetic appearance and stressed the use of a plastic ball inserted in Tenon's capsule, or into the eviscerated globe. This was followed by an excellent discussion by Dr. C. C. Johnson of Boston on the "Selection of operations for ptosis." The final paper in the symposium was by Dr. Ira S. Jones of New York, on the "Surgery of orbital tumors."

The scientific session on Monday afternoon was held at the Royal Victoria Hospital to which the group moved by buses. It was given in the main by the staff of the Hospital. Dr. J. C. Locke was in the chair.

Dr. John H. Dunnington of New York was the guest-of-honor and presented an excellent, rational discussion of "The surgical management of horizontal strabismus." He stressed the features to look for in each case so as to plan a proper surgical approach.

Dr. William Turnbull and Dr. Jean Bouchard of Montreal discussed the successful treatment by ionizing radiation of a variety (48 cases) of conjunctival and corneal lesions. They stressed the proper selection of the type of radiation for each case, pointing out the importance of not injuring the lens. They liked repeated small doses, and apparently had had excellent results with a minimum of serious damage to the eye.

The next paper was by Dr. Sean B. Murphy of Montreal, on the "Ocular aspects of head injury." He reviewed the signs in 224 cases. He found that the eye signs were not in any way related to the site of the skull fracture, should such be present. Signs were most frequent in closed fractures. Pupil reactions were varied. There were 25 cases of cranial nerve involvement; the fourth and the sixth nerves were the most frequently involved.

The final afternoon presentation was a most timely paper by Dr. G. Keith Edwards of Montreal, on the technique of "The collection, storage and selection of human vitreous for use in retinal detachment surgery." Dr. Edwards stated that the possibility of bacterial contamination is always present. He presented a carefully developed program whereby this danger can be minimized.

On Tuesday morning, April 7th, the meeting reconvened at the Queen Elizabeth Hotel with Dr. Jules Brault of Montreal, in the chair.

The first paper was by Dr. P. Robb McDonald of Philadelphia, a general discussion of "The present status of retinal detachment surgery." This excellent survey was followed by a symposium on "Recent advances in glaucoma." This was under the leadership of Dr. Roland J. Viger of Montreal. Dr. Andrew F. deRoetth, Jr., of New York discussed "Tonography and provocative tests." He uses the Mueller electric tonometer with the Sanborn recording galvanometer. He finds this and the water-drinking test the two most useful tests in borderline cases. Next, Dr. H. Saul Sugar of Detroit, discussed the "Present status of gonioscopy." By means of beautiful slides the character of the changes in the filtration angle were fully discussed and demonstrated. Dr. Robert Trotter of Boston, discussed the "Recent advances in glaucoma medical treatment." He surveyed various types of new and old antiglaucoma drugs. The symposium was closed by two authoritative discussions: one by Dr. Paul A. Chandler of Boston, on the "Surgical treatment of angle-closure glaucoma," and the other by Dr. A. J. Elliot of Toronto, on the "Surgical treatment of open-angle glaucoma."

For the afternoon session, the group moved by means of buses to the Montreal General Hospital. Dr. B. Alexander of Montreal was in the chair. The session was opened by an interesting description by Dr. Samuel T. Adams, Montreal, of his experience with eight cases of "Retinal detachment caused by macular and small posterior holes." The great difficulty of successfully treating these cases became apparent.

This was followed by a round-table conference on "Detachment of the retina," under the leadership of Dr. Samuel T. Adams. This discussion was both interesting and entertaining. It was conducted in a manner slightly different from the usual panel. Dr. Adams had prepared very complete case histories of a series of detachment cases with detailed charts of the fundi. These were presented to the panel members without previous briefing for presentation of their strategy and surgical approach. As might be expected, a number of approaches for each case were presented and authoritively discussed and debated. The fact that a variety of surgical approaches was presented in each case was far from being confusing; on the contrary the discussion was most helpful. The panel members were Dr. Robert J. Brockhurst of Boston, Dr. Graham Clark of New York, Dr. P. Robb McDonald of Philadelphia, Dr. L. Harrell Pierce of Baltimore, and Dr. Donald M. Shafer, New York.

The final meeting of the Ophthalmological Section was held on Wednesday, April 8th, and as usual opened with a scientific session at the Queen Elizabeth Hotel. Dr. John V. V. Nicholls of Montreal was chairman. The first paper was by Dr. Michel Mathieu of Montreal on "Microphthalmos with orbital cyst: A case report." This was a most extraordinary case. It occurred in an infant, in whom there was a large retrobul-

bar cyst communicating with the posterior of the right eye. This was removed successfully with retention of the eyeball.

Dr. P. Robb McDonald of Philadelphia presented a most instructive discussion of the "Management of traumatic lesions of the globe." He dealt with the removal of magnetic and nonmagnetic foreign bodies from various parts of the eye and the handling of complications.

Dr. Harry Magder of Montreal, presented a "Clinical observation in central serous retinopathy." In this he reported on a new test for this condition, making use of fatigue of the retina by means of bright light. The corrected visual acuity is taken and then the retro-fundus is exposed to the light of an ophthalmoscope for 15 seconds, following which the time required for the visual acuity to return to normal is recorded. In normal patients the time is less than 60 seconds. But in patients with this condition it may take a full hour. The test is apparently selectively positive in this condition.

Dr. Andrew F. deRoetth, Jr., of New York discussed "Applanation tonometry." Dr. deRoetth discussed the comparable findings of this instrument with those on a Mueller electric tonometer. Ninety percent of the readings were the same. The applanation tonometer was more accurate in cases of glaucoma with high myopia. However, in fully 10 percent of the patients, in those who were hyperactive and apprehensive, the applanation tonometer either cannot be used, or gives very inaccurate results. In these cases the depression tonometer is much more accurate.

These papers were followed by a symposium on the techniques of keratoplasty under the leadership of Dr. Michel Mathieu of Montreal. Dr. R. Townley Paton of New York, gave an excellent illustrated discussion of "The use and techniques of penetrating keratoplasty." He presented a moving picture of the method of performing a transplant on an aphakic patient. Dr. H. L. Ormsby of Toronto discussed the application of "Lamellar transplants." He favors their use in all cases where the anterior part of the cornea only is involved. Even in some cases where the posterior cornea is involved, they may cause great improvement in vision. He feels it is a safer procedure for the beginner. Dr. Brendan D. Leahey of Boston, discussed the "Complications of keratoplasty." The commonest one was glaucoma which occurred in 33 percent of cases.

In the afternoon, the members and guests moved to the Montreal Children's Hospital by bus, where under the chairmanship of Dr. Samuel T. Adams, an excellent program was presented.

The first paper was by Dr. Alfred J. McKinna of Montreal, on "Traumatic cataract in children: Treatment and results." He showed that needling cataracts in children is a potentially serious procedure, and must not be undertaken lightheartedly. Needling in such cases must be considered not only as a threat to the eye but as a threat to the vision.

Dr. Paul A. Chandler of Boston, gave an excellent survey and discussion of "The surgery of congenital cataract and congenital subluxation of the lens." He advocated conservatism and caution. Operation should only be considered when the vision is poorer than 20/50.

Dr. John V. V. Nicholls of Montreal, presented a paper on "The office management of patients with a reading difficulty." It was the author's experience that the ocular mechanism rarely, if ever, played an initiating part in the occurrence of reading difficulties. Defects in refraction or in ocular muscle balance are no more frequent in the child with reading difficulty than in control groups. Dr. Nicholls emphasized the importance of the ophthalmologist taking a leading role in co-ordinating the investigation of these patients, and seeing that the patient is channeled to the proper therapeutic unit. He pointed out how the majority of the

patients may be helped by appliciation of simple teaching procedures where phonics are emphasized.

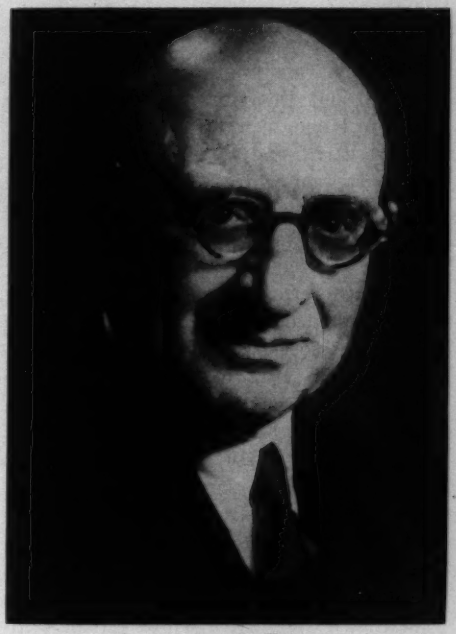
Finally, Dr. R. Alan Bourne of Montreal discussed the "Results of treatment of dacryocystitis in children." He reported on 63 cases. He advocated an early and conservative approach and the use of a probe only after other conservative means have been tried.

And so concluded an enjoyable and instructive three days. Dr. J. C. Locke and his local committee are to be congratulated on a splendid meeting.

John V. V. Nicholls.

OBITUARY

ANDRÉ MAGITOT, M.D.
1877-1958



ANDRÉ MAGITOT, M.D.

With the demise of Magitot one of the world's great ophthalmologists passes into history. His sudden death on September 6, 1958, as he was about to leave for the International Congress of Ophthalmology at Brussels to preside at a breakfast tendered by the staff of the Annales d'Oculistique had a tragic histrionic quality appropriate to his mutable career.

Emile Magitot, his celebrated father, left the ancestral home in Champagne to pioneer in making a medical specialty of odontology and was elected to the Academy of Medicine in 1882. André was born in Paris on August 11, 1877. The wild youth was expelled from Parisian schools and finished his secondary education at Nantes. Because of his splendid physique, athletic prowess, and aptitude for leadership he would have chosen to enter the Naval Academy were it not for his myopia and weakness in mathematics. Deciding on medicine, he became *interne des hôpitaux* in Paris (1903-07) and, inspired by Morax, committed himself to ophthalmology. On his mentor's advice he studied under Axenfeld, Fuchs and Abadie. He earned the doctorate in medicine in 1908 with a notable thesis on the vascularization of the optic nerve and chiasma, in which he demonstrated that the central vessels of the retina have no anastomoses with the circulation of the optic nerve. Magitot replaced Béal as assistant to Morax at Hôpital Lariboisière (1908-12). His investigations on the embryology of the retina and vitreous body emphasized the histogenesis of the visual cells. In 1911, came his greatest achievement, the initiation of successful lamellar keratoplasty. He demonstrated the viability of the cornea after death and established that 4°C. was the optimum temperature for its conservation. He used both round and square grafts, showed that only homografts would take, and that grafts from the corneas of stillborn were inferior to those from adults. He extended this work to therapy by replacing the head of a recurrent pterygium with a lamellar graft. In 1913 he was designated *ophtalmologiste des hôpitaux de Paris* and was appointed attending ophthalmologist at Hôpital Saint-Antoine.

While serving in World War I he modified the Krönlein operation, and studied traumatic myopia and traumatic glaucoma. Demobilized and decorated as chevalier of the Legion of Honor, he returned to Lariboisière, active research, and participation in the annual courses on ocular histopathology which many Americans, including Conrad Berens and myself, attended. At this time he investigated the aqueous humor and began his lifetime effort to prove the neurovascular theory of the pathogenesis of glaucoma of which he was the most extreme and insistent proponent. From 1912 to 1954, he wrote 28 articles on glaucoma, including two in English (THE JOURNAL, 8:761, 1925; Arch. Ophth., 6:647, 1931). Magitot's views on the aqueous and on glaucoma are essentially those elaborated by Duke-Elder later. In the 1958 Bowman Lecture, Duke-Elder stated that the glaucomatous eye is a sick eye in a sick body. Magitot phrased the epigram somewhat differently, that one cannot separate the organ from the organism.

Magitot's monograph on *The Iris* appeared in 1921. In 1926 he became attending ophthalmologist also at Hôpital Tenon, and in 1928 he was appointed to the faculty of the *College de France*. His career reached its height in 1936 when he succeeded Morax at Lariboisière and as editor-in-chief of the *Annales*. But with the Nazi occupation in 1940 Magitot became a victim of their program of racial persecution since his mother was of Jewish origin. His palatial home was seized by German generals and his assets confiscated. Practically destitute he fled from the Gestapo until the Resistance Force provided him asylum in a refuge for the aged in southwest France, while his wife and his two daughters made the perilous escape to Switzerland. In his shelter he completed the text on *Clinical Ocular Physiology*, published later in 1946.

On Magitot's return to Paris his former hospital positions were no longer available because of the retirement age, but the *Annales* was his still and became his special mission. At the private hospital where he now operated a mishap with an automatic operating table caused a cranial injury which necessitated emergency surgery from which complete recovery fortunately ensued. In 1952, Magitot and Bailliart published *Manual of Ophthalmology*, a text for students. Edward Hartmann, who succeeded Magitot at Lariboisière, is now editor-in-chief of the *Annales*. Magitot was the only French ophthalmologist who was an honorary member of the American Medical Association. He was also an honorary member of the Pan-American, Hellenic and Belgian societies of ophthalmology.

James E. Lebensohn.

CORRESPONDENCE

HUMMELSHEIM OPERATION

Editor,
American Journal of Ophthalmology:

Drs. Don M. Smart and D. Snydacker published a case of "Successful Hummelscheim operation" in THE JOURNAL, 47:89-90 (Jan. Pt. I) 1959.

It is not quite clear whether they considered this a paralysis or a paresis, the difference being what the definitions imply. Which is quite a bit. In the second paragraph of their paper they convey their opinion that this was a paralysis and not a paresis.

I regret to disagree with this opinion, for the presented case obviously was that of an incomplete paralysis, in other words a paresis, probably on a luetic basis.

In a paper published in the *Eye, Ear, Nose and Throat Monthly* (37:511-515 [Aug.] 1958) I made an effort to analyse the Hummelscheim procedure and I believe I was able to prove that this method cannot possibly give good results in cases of complete abducens paralysis, whatever the etiology should be.

The authors themselves supply some proof of the facts in their photographs of the case within the paper and these do not quite uphold their own observations on the true nature of their case. Still better proof would be the analysis of photographs before any surgery was done. It should be borne in mind that a paresis is likely to improve spontaneously with time, whereas a complete paralysis seldom does.

Let us look at the photographs of the cases as published: Figure 1 shows that the lateral gaze is by far not extreme. The corneal reflex of the *left* eye shows a right lateral gaze of not more than 15° and at the same time the supposedly paralysed *right* eye shows an abduction of more than half of that. Figure 2 shows the corneal reflex left of the center in *both* eyes which means that the eyes were at a slight lateral gaze. Allowance for the lateral position of the illumination notwithstanding. There is an esotropia of a slight degree visible here, the corneal reflex of the right eye being a little closer to the left limbus. Figure 3 shows a marked loss of adduction in the right eye, most likely due to the recession of the right medial rectus muscle.

Observation of the corneal reflexes in Figure 4 shows almost perfect abduction of the right eye, while the left eye is in near maximum adduction. Figure 5 shows that the "straight ahead position" is in fact a slight lateral gaze to the left, the corneal reflex of the *left* eye being off center to the left (of the observer). At the same time the corneal reflex of the *right* eye shows a more pronounced decentration to the *right*, showing the residual esotropia in this position.

Figure 6 shows an incomplete left lateral gaze of the *left* eye while the right eye shows a marked weakening of the function of the right medial rectus. The corneal reflex is at the center of the right cornea, revealing that the right eye is unable to turn in beyond the center line in this position.

These observations clearly show that the result here is exactly what we find after many cases of routine recession-resection operations. Dr. Callahan is perfectly right when he claims that good results after Huemmelscheim operations are due not to the transplant, but to the resection-recession performed. Good result is possible only in cases of incomplete and not in cases of complete abducens paralysis.

The remedy: Complete transplant of the whole superior rectus in cases of complete abducens paralysis.

The last line of Drs. Smart and Snydacker is in accordance with facts, inasmuch as "selected cases" should mean paresis and not paralysis of the abducens.

(Signed) Frank A. Vesey,
Toledo, Ohio.

* * * *

Reply

Editor,
American Journal of Ophthalmology:

Dr. Vesey has properly emphasized that one of the problems involved in connection with lesions of the 3rd, 4th, or 6th cranial nerves is the differential diagnosis between paresis and paralysis. Lacking electromyography, the only way we know of differentiating between the two is by clinical observation of the patient's ability to move the eye into the sphere of action of the involved muscle or muscles. Most authorities agree that complete absence of any movement into the sphere of action of the involved muscle which persists for six to eight months indicates a paralysis. What seemed so obviously a paresis to Dr. Vesey appeared to us on examination of the patient to be a paralysis.

A second important point is even more difficult to evaluate. In the continuing controversy over the Hummelsheim operation, there is a lack of scientific control that is always inherent in clinical medicine. This simmers down to trying to decide whether in our case, for example, the result would have been better if a repeated recession and re-

section had been done than was actually achieved by the technique we used.

It was precisely because we thought that the Hummelsheim operation, as we did it, gave better results than a simple recession-resection would have, that we felt it was worth reporting. It will be recalled that this patient had had a previous recession of the right medial rectus and a resection of the right lateral rectus. In spite of the combined procedure, 25Δ of esotropia remained and the right eye could be abducted only barely past the midline. This situation prevailed for seven months without change. On the basis of the clinical findings and the length of time which they had been present, it was assumed that a paralysis existed, that it was permanent, and that it had not been materially improved by the recession-resection.

Although a picture is worth a thousand words, Dr. Vesey is not altogether on firm ground in questioning the clinical findings on the basis of the published pictures. As a matter of fact, the preoperative pictures, in our opinion, show exactly what they are described as showing: an esotropia in the primary position; markedly limited dextroversion which is the result of the paralysis of the right lateral rectus, and the surgically weakened left medial rectus; and fairly good levoversion but with some lag of the right eye because of the surgically weakened right medial rectus.

The very definite improvement in abduction of the right eye which immediately followed the Hummelsheim operation is ascribed to the effect of the tendon transplantation since we deliberately did nothing to the lateral rectus except detach it and reattach it two mm. anterior to the original insertion as a necessary part of our technique.

Incidentally, the correct spelling is: HUMMELSHEIM and the U does not have an umlaut.

As Alexander Pope wrote:

"'Tis with our judgements as our watches, none
Go just alike, yet each believes his own."

(Signed) Daniel Snydacker and
Don M. Smart
Chicago, Illinois.

EFFECT OF ALPHA-CHYMOTRYPSIN ON CAT-GUT SUTURES

A study was made on the effect of alpha-chymotrypsin on cat-gut sutures. The sutures used were Davis and Gech, Inc. (USP, surgical gut, eye, 6-0 chromic). A balance pan was suspended by the test sutures until the test suture broke. The tensile strength of the sutures as removed from the ampules was found to be 225 gm. on three duplicate determinations with as many different sutures. Nine sutures were removed from their ampules, washed thoroughly with water, then distilled water, and placed in a 1:5,000 dilution of zolyse (diluted with the balanced salt solution diluent) and incubated at 37°C. At the end of 72 hours, the sutures were removed from the solution and tested by the method already explained.

The nine sutures tested broke at the following weights: 170, 220, 225, 235, 230, 235, 210, 215 and 200 for an average of 215 gm. As compared with the tensile strength of 225 gm. for three untreated sutures, this indicates that, after 72 hours' exposure to a solution of alpha-chymotrypsin corresponding to the dilution normally used in surgery and exposed to a temperature approximately that of the human body, there was little, if any, damage to the suture by the action of the enzyme. In addition, examination under the microscope showed no indication of damage by the enzyme.

(Signed) T. C. Fleming and
Warren W. Binion,
Fort Worth, Texas,

BOOK REVIEWS

TRANSACTIONS OF THE OPHTHALMOLOGICAL SOCIETY OF THE UNITED KINGDOM: Volume LXXXVIII, Session 1958. 740 pages and index. London, J. and A. Churchill, Ltd. Price: not listed.

As in previous years this stout volume is primarily a record of the annual congress of the Ophthalmological Society of the United Kingdom and of the Oxford Ophthalmologic Congress. Other British ophthalmologic societies are represented largely by title. A wide variety of topics is presented and perhaps only the superb quality of the prose distinguishes these from similar meetings held in the United States. Three papers on hypermature cataract are in agreement on the advisability of removing such lenses before complications develop. Three papers on toxoplasmosis echo the uncertainty found in this country as to the importance of this entity in the etiology of uveitis. Precancerous melanoma of the conjunctiva comes in for its share of discussion in three papers by Healy, Lederman and Wells. One of the most interesting and at the same time gruesome papers in this volume is that by Dorothy Miller on the development of cataracts in a patient with anorexia nervosa. The photographs of the patient under discussion might well supplant nagging as a method of getting children to eat.

Redmond Smith's paper on the incidence of the primary glaucomas completely upsets the usual thoughts on the relative frequency of closed-angle and simple glaucoma It has been generally held both here and abroad that open-angle glaucoma is at least three or four times as common as closed-angle. In the present paper the author finds that the incidence of closed-angle glaucoma is at least twice that of open-angle. One can only surmise that interpretation of gonioscopy remains a subjective phenomenon.

The Oxford Ophthalmologic Congress proceedings begin with three papers on vascular changes in progressive visual loss. Of particular interest is a paper by D. P. Choyce on "Anterior chamber acrylic implants," and an excellent article by Dr. Paton of New York on "Keratoplasty for Fuchs' dystrophy."

A symposium on the cataract section held by the Irish Ophthalmological Society is included in this volume and the eternal argument of Graefe knife vs. keratome apparently goes on in some quarter of the globe at all times. Dr. Ridley's comments on "slashers and scratchers" are particularly amusing. Indeed all the articles in this volume are of good humor and make pleasant as well as informative reading. They are worth perusing.

David Shoch.

THE ROLE OF THE OPHTHALMOLOGIST IN THE REHABILITATION OF BLIND PATIENTS. By S. Finestone and S. Gold. Morristown, N. J., The Seeing Eye, and New York, American Foundation for the Blind, 1959. 75 pages, paperbound. Price: $0.75.

This report is based on a questionnaire sent to 500 selected members of the American Academy of Ophthalmology and Otolaryngology from which a total of 190 returns was received. The help from Dr. Frank W. Newell, secretary of the National Committee for Research in Ophthalmology and Blindness is gratefully acknowledged. Hope for recovery of vision is a major deterrent to adjustment to blindness. The ophthalmologist should inform his patient without undue delay of the fact of blindness and its cause, and should help him to become acquainted with the various rehabilitation agencies. One ophthalmologist wrote that those who have not worked with the blind have little knowledge of the services available to them, and that the training in ophthalmology does not touch upon any aspect of dealing with blindness. Ophthalmologists who appreciate the problems of the blind in regard to emotional adjustment, economic support and travel are

most likely to suggest community services. The inevitable conclusion is reached that ophthalmologic practice has a greater potential for rehabilitative influence upon blind persons than is currently exercised.

James E. Lebensohn.

CURRENT THERAPY—1959. Edited by Howard F. Conn, M.D. Philadelphia and London, W. B. Saunders Company, 1959. 781 pages. Price: $12.00.

The new edition of *Current Therapy* contains little of interest to ophthalmology. It has never been the practice of the editor of this volume to include more than a cursory mention of a few isolated conditions involving the eye, although most other specialty fields have a respectable representation. Of over 300 contributors who give their individual methods of treatment of various conditions there will be found the name of only one ophthalmologist who has been given meager and inconsequential space. The volume will therefore be of interest to ophthalmologists only as a reference book for current therapeutic practice in nonophthalmologic fields. Of value is a list of common poisons and the active ingredients in various commercial products.

William A. Mann.

STRABISMES: HETEROPHORIES PARALYSIES OCULO-MOTRICES. René Hugonnier. Paris, Masson et Cie, 1959. 748 pages, 230 illustrations, references, index. Price: Not listed.

Dr. Hugonnier is an ophthalmologist of the hospitals of Lyon, France. He is director of the service of ocular motility and the school of orthoptics at the University Clinic of Lyon. Louis Paufique, the professor of clinical ophthalmology to the Faculty of Lyon, has written a preface to this work expressing his appreciation and praise. He says, "The French School, which has brought such important contributions by Javal, Parinaud, Cantonnet, Remy Onfray to the study of strabismus, can no longer remain apart from the movement, principally of anglo-saxon origin, that has transformed the study and practice of the treatment of strabismus during the last twenty years." He further says, "This book is the fruit of a long effort. It is written in simple language, accessible to all, ophthalmologists, students and even to the auxilliary orthoptists. No detail has been neglected. All the necessary facts, photographs, designs and schemas allow one to follow the descriptions."

It is too bad for most of us that this book is, of course, written in French. It is beautifully prepared and illustrated. The lucid style of the author, so characteristic of French authors, does, as Paufique says elsewhere in his preface, permit us to follow his teaching "with very great interest."

There are 50 chapters, some long, others very short, that systematically progress through the subject from anatomy and physiology, nonparalytic squint, paralytic squint, methods of examination, the nonsurgical and the surgical treatment and finish with general conclusions and some delightful aphorisms, for example, "The patient is more satisfied with comfortable vision than with a beautiful diagnosis" or "The mental age of the child? Certainly, that of the parents has no less importance."

In his foreword, the author promises to be "sufficiently complete, but before everything, entirely simple and clear." I am sure that the reader will agree that he has fulfilled this promise and has given us a first class and modern book on strabismus. It is the result of Dr. Hugonnier's long experience in the clinic, and many hours of study of the world's literature on the subject. It is too bad that there is no English edition, for it is a sound exposition of a confusing subject.

Derrick Vail.

ABSTRACT DEPARTMENT

EDITED BY DR. F. HERBERT HAESSLER

Abstracts are classified under the divisions listed below. It must be remembered that any given paper may belong to several divisions of ophthalmology, although here it is mentioned only in one. Not all of the headings will necessarily be found in any one issue of the Journal.

CLASSIFICATION

1. Anatomy, embryology, and comparative ophthalmology
2. General pathology, bacteriology, immunology
3. Vegetative physiology, biochemistry, pharmacology, toxicology
4. Physiologic optics, refraction, color vision
5. Diagnosis and therapy
6. Ocular motility
7. Conjunctiva, cornea, sclera
8. Uvea, sympathetic disease, aqueous
9. Glaucoma and ocular tension
10. Crystalline lens
11. Retina and vitreous
12. Optic nerve and chiasm
13. Neuro-ophthalmology
14. Eyeball, orbit, sinuses
15. Eyelids, lacrimal apparatus
16. Tumors
17. Injuries
18. Systemic disease and parasites
19. Congenital deformities, heredity
20. Hygiene, sociology, education, and history

1

ANATOMY, EMBRYOLOGY, AND COMPARATIVE OPHTHALMOLOGY

Vrabec, F. **Studies on the corneal and trabecular endothelium.** Brit. J. Ophth. **42**:667-673, Nov., 1958.

As the corneal epithelium approaches the periphery it passes over the margin of Descemet's membrane into the trabecular meshwork where its cells undergo a transition in shape in that they become elongated in the meridional direction. The cement substance often increases in thickness and may cover the whole surface of the cells with a thin argyrophil layer; this cement might possibly aid in the flow of aqueous fluid over this area. (5 figures, 14 references) Morris Kaplan.

Weimer, V. L. **The sources of fibroblasts in corneal wound repair.** A.M.A. Arch. Ophth. **60**:93-109, July, 1958.

Studies of the normal pattern of wound healing were carried out on adult rat corneas; 75 percent of the corneal stromal cells were transformed into fibroblasts in the first 24 postoperative hours and the remaining 25 percent were not transformed. Stromal cells were the origin of 35 percent of the total number of filbroblasts. The remainder were derived from monocytes. Formation of fibroblasts was complete in 60 hours. (24 figures, 5 tables, 28 references) G. S. Tyner.

Wolter, J. R. **Secondary degeneration of the human retina.** A.M.A. Arch. Ophth. **59**:731-745, May, 1958.

The silver carbonate methods of del Rio Hortega make it possible to visualize normal and pathologic structures of the human retina which are not accessible with the conventional histological techniques. This paper presents the features found by this type of examination in a case of advanced secondary degeneration of the retina. In this case the diagnosis was dislocation of the lens, secondary glaucoma, active iritis, and old disseminated chorioretinitis. The pathology of the choriocapillaris, pigment epithelium, retina, and the optic disc were of special interest. It is the hope of the author that this case report may help stimulate new interest in histologic details of the cellular reaction, since these details actually determine the nature and course of an eye disease. (20 figures, 13 references) E. J. Swets.

2
GENERAL PATHOLOGY, BACTERIOLOGY, IMMUNOLOGY

Braley, Alson E. **Ocular allergies.** Tr. Am. Acad. Ophth. **62**:826-834, Nov.-Dec., 1958.

In this summary of the recent knowledge of allergy as applied to the eye, allergy is divided into two types, 1. the immediate or anaphylactic reaction, and 2. delayed or bacterial hypersensitivity. Anaphylactic lid reaction is the most common type of ocular allergy. It is characterized by edema and itching. Dry eczema is like the Arthus phenomenon and moist eczema is like the Schwartzman phenomenon. Bacterial and contact allergies also occur.

Acute allergic conjunctivitis is anaphylactic. Acute dermatoconjunctivitis may be immediate or delayed. Chronic allergic conjunctivitis may be atopic (immediate) or bacterial (delayed). Local irritation is differentiated from local allergy; in local irritation the conjunctiva is hyperemic, there are follicles on the tarsus, itching is milder, and the disturbance follows exposure to an irritant rather than being seasonal whereas the conjunctiva is pale in local allergy and has a smooth or slightly papillary surface. Braley recognized two types of vernal conjunctivitis, one atopic and the other acquired.

Three basic types of corneal allergy are described. First, there is corneal edema with or without deep vascularization. This may be atopic or bacterial. Secondly, there is phlyctenular keratoconjunctivitis, probably due to sensitivity to a product of the tubercle bacillus. Disciform keratitis is believed to be an anaphylactic reaction. Thirdly, there are marginal infiltrates and ulcers. These reactions are allied to the Arthus phenomenon.

Corticosteroids and vasoconstrictors are the drugs of value in ocular allergy. Antihistaminics have been disappointing. (11 references) Harry Horwich.

Busse Grawitz, P. **The influence on keratitis of inflammatory lacrimal secretion.** Arch. f. Ophth. **160**:388-410, 1958.

Direct microscope observation of the development of a keratitis is possible in the experimental animal and it confirms the concepts of molecular pathology. It shows that all corneal inflammatory cells arise in loco and remain at their site of origin; no blood cells from the marginal network are added. The inflammatory lacrimal secretion contains substances which transform the cells of mammalian tissue which has been placed beneath the lid into leukocytes. The in situ corneal reactions which arise six hours after trauma in the central area of the cornea are ascribed solely to this factor. Normally it is a lacrimal function to leach out and carry away toxic substances which arise in the cornea. Even severe conjunctivitis does not produce such inflammation in the uninjured cornea. The cells which are found in the tears during inflammation are superficial conjunctival cells which have become more or less leukocytic. (5 figures, 20 references) F. H. Haessler.

Bussey, J. L., Shafer, D. M. and Hughes, I. A. **Studies on the antibacterial properties of human vitreous.** A.M.A. Arch. Ophth. **61**:233-238, Feb., 1959.

Contamination studies were done with human vitreous to determine if it possessed any self-sterilizing properties; S. pyogenes var. aureus was used in various dilutions to contaminate vials of human vitreous. If fewer than 1,500 organisms were injected into the vial containing 2 cc. of vitreous, the refrigerated vitreous uniformly became sterile within 48 hours. Blood agar plates that had been streaked with various known organisms were studied for zones of inhibition around small pools of vitreous as well as around standard antibiotic discs. Definite zones of inhibition were noted on plates seeded with S. pyogenes var. aureus, Koch-

Weeks bacillus, Proteus vulgaris, and Pseudomonas aeruginosa. On all but the Pseudomonas plate the zones of inhibition were larger around the vitreous pools than around the antibiotic discs. It is not known what factor or factors are responsible for this antibacterial activity of human vitreous. (5 figures, 2 tables, 8 references) William S. Hagler.

Cogan, D. G. and Kuwabara, T. **Ocular changes in experimental hypercholesteremia.** A.M.A. Arch. Ophth. **61**:219-225, Feb., 1959.

The ocular findings in hypercholesteremic rabbits are described. Gross xanthoma-like plaques occur in the posterior portions of the iris stroma. Microscopically these lesions consist of sudanophilic lipid and birefringent crystals contained in tumor-like accumulations of macrophages. Similar lesions are seen in the ciliary body, sclera, and choroid. Comparable lesions have not been described in man.

The cornea of hypercholesteremic rabbits contains an arcus which is not similar to the arcus senilis in man. The arcus in rabbits is superficial, does not spare the paralimbal region, and is always vascularized. Microscopically it consists of globular intracellular lipid situated in the superficial stroma. This is in contrast to the arcus in man which consists of diffuse sudanophilia of Bowman's and Descemet's membranes and a granular extracellular sudanophilia of the entire thickness of the peripheral stroma.

Trauma of the cornea, iris, and sclera in hypercholesteremic rabbits results in plaques which are similar in all respects to the lipid plaques which develop at sites of trauma in man with systemic xanthomatosis and hypercholesteremia. (8 figures, 30 references) William S. Hagler.

Craft, Kenneth L. **Allergic dermatoses in ophthalmology and otolaryngology.** Tr. Am. Acad. Ophth. **62**:870-873, Nov.-Dec., 1958.

The author divides allergy into two main types; contact or venenata and atopic or intrinsic. The former includes cosmetics, danders, drugs, plants, molds, industrial chemicals, clothing, soaps, dentures, metals, and insecticides. The latter is usually hereditary and is due to foods or drugs. The former usually gives a negative scratch test but a postive patch test; the latter usually gives a positive scratch but a negative patch test.

Several examples of each type of allergy are described. Harry Horwich.

Dunnington, J. H. and Smelser, G. K. **Incorporation of S^{35} in healing wounds in normal and devitalized corneas.** A.M.A. Arch. Ophth. **60**:116-129, July, 1958.

The authors evaluated the importance to healing of cell constituents at the edge of a fresh wound and describe the time and site of formation of sulfated mucopolysaccharides in a cornea recovering from injury. The normal cell constituents of connective tissue adjacent to the wound are most important since there is a considerable delay in the influx of other cell elements. When wound healing is delayed, the final healing is imperfect. (14 figures, 15 references) G. S. Tyner.

Toussaint, D. **Teratogenic effect of trypan blue on the eye of the rat.** Bull. Soc. belge d'opht. **119**:460-472, 1958.

This study was undertaken to determine the effect of diverse doses of trypan blue, injected subcutaneously, on the progeny of 27 pregnant rats. Five rats were injected three times on the 7th, 8th and 9th day after conception. Four rats served as controls. Twelve cases of cataract, two of bilateral anophthalmos, seven of unilateral anophthalmos, three of bilateral microphthalmos, 15 of unilateral microphthalmos, and six anomalies of the primary optic vesicles were found. The in-

jected color could not be seen in the fetal tissues but the maternal structures were densely permeated. A damaging influence of the dye on the hormonal control of pregnancy was considered to be one of the explanations for the occurrence of the grave ocular congenital abnormalities. (12 figures, 10 references)

Alice R. Deutsch.

Zimmerman, Lorenz E. **Application of histochemical methods for the demonstration of acid mucopolysaccharides to ophthalmic pathology.** Tr. Am. Acad. Ophth. **62**:697-703, Sept.-Oct., 1958.

Acid mucopolysaccharides (AMP) were studied by means of the Rinehart-Abul-Haj modification of Hale's colloidal iron procedure, and variations of Steedman's alcian blue technique. In the retina AMP was found only in the rods and cones layer and especially in the outer members which were coated with a matrix of stain. Degeneration of this layer is attended by a loss of AMP. Pale staining AMP is found in the mycrocysts of peripheral degeneration.

The retinoblastoma rosette contains AMP, as do the spaces in cavernous atrophy of the optic nerve and areas of myxomatous degeneration in gliomas of the optic nerve. (19 references)

Harry Horwich.

3

VEGETATIVE PHYSIOLOGY, BIOCHEMISTRY, PHARMACOLOGY, TOXICOLOGY

Agarwal, L. P. and Malik, W. R. K. **Ocular indications of Diamox.** Ophthalmologica **136**:178-185, Sept., 1958.

Diamox is useful for reducing the tension preoperatively in glaucoma, in eyes with a shallow chamber, to prevent cystic scars, and for the prevention of complications in cataract surgery without iridectomy. Occasionally it may be useful when the tension rises with corneal ulcer or acute iritis. The mode of action is not definitely known but probably it reduces the formation of aqueous by inhibiting carbon anhydrase. (5 tables, 16 references)

F. H. Haessler.

Armaly, Mansour F. **Studies on intraocular effects of the orbital parasympathetic pathway. 1. Technique and effects on morphology.** A.M.A. Arch. Ophth. **61**: 14-29, Jan., 1959.

This experiment in the cat was prepared so that parasympathetic stimulation would produce effects limited to the intraocular structures, and yet be isolated from their central and peripheral connections. On sectioning the isolated central parasympathetic pathway there was marked dilitation of the pupil, recession of the anterior surface of the lens, increased depth of the anterior chamber, crowding and reduction in depth of the chamber angle, and a rise in the intraocular pressure. On stimulation of the parasympathetic pathway, there was marked constriction of the pupil, forward bulging of the central six millimeters of the anterior surface of the lens and an increase in tension of the ciliary muscle fibers. (4 figures, 12 references)

Irwin E. Gaynon.

D'Arrigo, P. and Petrosillo, O. **Excretion of 17 ketosteroid in urine after ultraviolet irradiation.** Arch. di ottal. **62**:497-502, Nov.-Dec., 1958.

The authors report a series of 10 male rabbits showing decrease in 17 K hormone in the urine after irradiation with ultraviolet light. They assumed a reflex acting through the vegetative nervous system. (1 table, 18 references)

Paul W. Miles.

Auricchio, G. **The osmotic pressure of the aqueous in the course of an anaphylactic uveitis in the rabbit.** Ophthalmologica **136**:217-223, Sept., 1958.

During anaphylactic uveitis the osmotic pressure of the aqueous sinks to the level of that of the plasma and no difference between aqueous of the anterior and posterior chamber was found. Either the secretion of aqueous is greatly inhibited or there is an excessive loss by diffusion of osmotically active substances in the posterior chamber. (4 tables, 3 references)

F. H. Haessler.

Basu, P. K. **Effect of different steroids on the healing of nonperforating corneal wounds in rabbits.** A.M.A. Arch. Ophth. **59**:657-664, May, 1958.

Reports of the inhibitory action of corticosteroids on wound healing have caused many eye surgeons to hesitate using them during the immediate postoperative period. The present study was devised to compare the actions of the different steroids in concentrations recommended for human therapeutic use on standard nonperforating corneal lesions in rabbits. It was found that there was no significant difference in wound healing, clinically or histologically, in the control and treated groups of these rabbits. The progress and rate of healing were similar in 80 percent of all the wounds. (8 figures, 6 tables, 10 references)

E. J. Swets.

Bettman, J. W., Fellows, V. and Chao, P. **The effect of cigarette smoking on the intraocular circulation.** A.M.A. Arch. Ophth. **59**:481-488, April, 1958.

The effect of nicotine and smoking on the intraocular vascular system is very poorly understood. Although it is widely assumed that smoking causes a generalized constriction of the intraocular blood vessels, this is not necessarily true. It is believed that nicotine stimulates and then depresses both the sympathetic and parasympathetic ganglia. In addition it stimulates the central nervous system and may act directly on the smooth muscle of the vessels to produce vasoconstriction. Patients may vary markedly in their vascular response to cigarette smoking. In this study blood flow was measured in the eyes of animals forced to breathe cigarette smoke. With the aid of radioactive isotopes measurements were made on fundus photographs with a micrometer. It was found that smoking increases the blood volume of the choroid in animals if the dose is high. In man the result may vary from vasoconstriction, no change, or vasodilation. (8 figures, 1 table, 28 references)

E. J. Swets.

Bulanda, Maria. **Use of Furacin in ophthalmology.** Klinika Oczna **28**:139-142, 1958.

Bacteriostatic and bacteriocidal activity of Furacin was tested by the author in vitro and in vivo. Various bacteria were used and it was found that staphylococci were killed in the highest dilution. A very strong solution was necessary for pseudomonas. It was also found that a solution containing 1 percent of Furacin did not irritate the eye. Furacin in 1/500 to 1/100,000 dilution was used in 98 patients with conjunctivitis, blepharitis and disturbances of the lacrimal pathways, and also in 38 patients with infected wounds. Beneficial effects were observed in all those conditions. (1 table, 10 references)

Sylvan Brandon.

de Carvalho, C. A. **Changes of the blood-aqueous barrier in rabbits as a result of tonography.** A.M.A. Arch. Ophth. **60**:25-30, July, 1958.

The author was able to determine a measureable increase in the permeability of the blood-aqueous barrier in rabbits after tonometry. (7 tables, 18 references)

G. S. Tyner.

Cascio, G. and Ponte, F. **Notes on some aspects of the hydration, in vitro, of the lens under various experimental conditions.** Ophthalmologica **136**:345-351, Nov., 1958.

The authors studied weight behavior of the lens in vitro, in relation to the various physiological liquids used as mediums—Tyrode's solution, aqueous humor, blood serum of the same species—and to the variations in ionic-salt content. They observed a lesser hydration of the lens in blood serum than in aqueous humor and proportionately also that in Tyrode's solution and believe that this phenomenon is due to the different proteic content of the medium. Finally they relate the diversity of weight behavior observed as a consequence of variations in ionic-salt content of the medium, to the well-known antagonism between Ca and K ions. (2 figures, 2 tables, 12 references)

Authors' summary.

Chandler, M. R. and Rosenthal, E. **The effect of intramuscularly administered trypsin on blood injected into the vitreous of the rabbit.** A.M.A. Arch. Ophth. **59**: 706-711, May, 1958.

It is the purpose of this paper to describe the effects of the use of intramuscularly administered trypsin on fresh blood introduced into the vitreous body of rabbits. While significant differences in the behavior of the blood clot in treated and control animals could not be discerned, the conditions of the experiment precluded definite therapeutic deductions. (4 figures, 1 table, 15 references) E. J. Swets.

Cohan, B. E. **Radiography of aqueous humor outflow.** A.M.A. Arch. Ophth. **60**: 110-115, July, 1958.

The authors demonstrated new details of the anatomy of the anterior chamber and its channels of outflow in the eye of the rabbit. The technique was based on radiography of the eye after replacing the aqueous humor with radio-opaque material. Excellent diagrams accompany the article. In addition to the usual aqueous veins there is communication with the venous plexus of the ciliary muscle. This, in turn, communicates with the vortex veins and laminary scleral veins. (5 figures, 12 references) G. S. Tyner.

de Conciliis, U. and Testa, M. **Electrophoretic research on hydrosoluble proteins of mitochondria from normal beef lenses.** Arch. di ottal. **62**:387-390, Sept.-Oct., 1958.

The authors found that 60 to 70 percent of mitochondria are of proteins which can be concentrated and isolated by centrifuge. Electrophoresis of these proteins showed some water soluble fractions. (1 figure, 7 references)

Paul W. Miles.

Dardenne, U. and Quint, K. R. **Experimental study of the use of cortisone and hydrocortisone.** Arch. f. Ophth. **160**:425-441, 1958.

An enzygmatic transformation of cortisone to hydrocortisone by the epithelium was not demonstrable. Hydrocortisone is modified more slowly than cortisone by the corneal epithelium and iris tissue as a result of hydration of the Δ-4-3 ketone grouping. Hydrocortisone is changed less rapidly than cortisone. The authors discuss the clinical significance of their data. (3 figures, 4 tables, 24 references)

F. H. Haessler.

Dark, A. J. **The distribution of lipids in the bovine lens and cornea.** A.M.A. Arch. Ophth. **59**:676-682, May, 1958.

The present study, in which histochemical procedures were used, deals with the distribution of lipid in general and of phospholipid in particular in the bovine lens and cornea. It was found that hitherto unknown lipid corpuscles exist in a restricted zone of the lens and a lipid component exists in the lens cement substance. Tonofibrils and intercellular bridges in the corneal epithelium contain phospholipids, and there is a rich accumulation of phospholipid in the corneal epi-

thelium, endothelium, and stromal cells as well as in the anterior lens epithelium. (11 figures, 19 references)

E. J. Swets.

D'Arrigo, Pasquale. **The concentration of 17-keto-steroid in the urine in vernal conjunctivitis.** Arch. di ottal. **62**:377-386, Sept.-Oct., 1958.

In health or in disease one can demonstrate as many as 42 steroids in the urine by chromatography. In previous work it had been suggested that a deficiency of steroid existed in vernal conjunctivitis, so studies of urinary steroid seemed logical. In 16 children with active vernal conjunctivitis, the concentration of 17-ketosteroid in the urine appeared to be decreased from one to three percent over normals. The author discusses the possibility of pituitary or other glandular involvement, and concludes that vernal conjunctivitis was evidence of pluriglandular abnormality. (2 figures, 1 table, 41 references)

Paul W. Miles.

Del Rio Cabanas, José Luis. **The biochemistry of light perception.** Arch. Soc. oftal. hispano-am. **18**:1107-1121, Nov., 1958.

The literature is reviewed.

Ray K. Daily.

McLaren, D. S. **The eye and related glands of the rat and pig in protein deficiency.** Brit. J. Ophth. **43**:78-87, Feb., 1959.

On a protein-deficient diet there is greater susceptibility to damage of the cornea in the rat, whereas the lens is affected in the pig. In view of the difference between the response to protein deficiency of the eyes in these two species, caution is urged in drawing conclusions regarding the effects of protein malnutrition of the eye in man. (12 figures, 2 tables, 12 references) Irwin E. Gaynon.

4

PHYSIOLOGIC OPTICS, REFRACTION, COLOR VISION

Borley, W. E. and Snyder, A. A. **Surgical treatment of high myopia: the combined lamellar scleral resection with scleral reinforcement using donor eye.** Tr. Am. Acad. Ophth. **62**:791-802, Nov.-Dec., 1958.

The history of surgical treatment for high myopia is briefly reviewed. The details of the surgical technique of resection are given. A strip of sclera from a donor eye is anchored just nasal to the inferior and superior rectus muscles to support the posterior portion of the eye.

Nine cases are reported on, ranging in age from seven years to 65. A decrease in myopia of 4 to 18 diopters was noted. Visual acuities, visual fields, and complications are presented. Indications for this procedure are myopic degeneration with hemorrhages and exudates, reduction of visual acuity to less than 20/80, visual field constriction with an enlargement of the blind spot and scotomas, and vitreous changes. Symptoms of great importance are blue vision and darkening of vision. (10 figures, 1 table, 18 references)

Harry Horwich.

Casanovas, José. **New optotypes.** Arch. Soc. oftal. hispano-am. **18**:1008-1015, Oct., 1958.

The author's chart for testing visual acuity consisting of a star and a circle has been modified to include two more optotypes, a cross and a square. He also describes a reading chart for near visual acuity, which consists of names, so that it is suitable for any language. (7 figures, 1 table, 7 references) Ray K. Daily.

Cruces Aspilche, Manuel. **Jackson's cross cylinder in the correction of astigmatism.** Arch. Soc. oftal. hispano-am. **18**: 811-840, Aug., 1958.

The Jackson's cross cylinder is not widely known in Spain. The author describes comprehensively the optical properties of this device, its action on the ocular dioptric system, and its clinical application in the correction of astigmatism. He finds it useful in refraction by the subjective method, as a part of a refraction pattern which includes skiascopy and ophthalmometry, for checking final results arrived at by other methods, and in the biastigmatic method of Marquez; in the latter method it is used to find the axis and strength of the residual astigmatism, after the corneal astigmatism has been determined by the ophthalmometer. Six cases illustrate the clinical application. (8 figures, 29 references)

Ray K. Daily.

Curtin, B. J., and Teng, C. C. **Scleral changes in pathological myopia.** Tr. Am. Acad. Ophth. **62**:777-790, Nov.-Dec., 1958.

Ten pathologically myopic eyes were studied; they averaged about five millimeters greater in length than normal eyes, and the sclera was about three-fourths normal thickness, except at the posterior pole where it was only one-third normal thickness.

The microscopic changes were very marked in the meridional bundles and were best seen in the thinned areas. The most consistent finding was a thinning of the fiber bundles. A reduction in refringency of the normal longitudinal light reflex along the margin of the fiber bundle was found. There was also loss of the dark longitudinal fiber striations. In the equatorial bundles there was separation of the fibers, reduction in fiber size, and dispersion or splaying of fibers. In higher grades of myopia, a cornea-like composition occurs and is due to an absence of cross bundles. In other instances the sclera may become amorphous or granular.

It is probable that fibrillogenesis is impeded and that immature or abnormal fibrils result. No significant changes were found in the cellular components or ground substance but more delicate staining techniques may be required to demonstrate them. It is presumed that there is a process of separation and slippage of the fibril-fiber components upon one another.

Ruedeman suggests similarities between pathologic myopia and osteogenesis imperfecta. (11 figures, 1 table, 24 references)

Harry Horwich.

Fonda, G. and Snydacker, D. **Optical aids for low visual acuity.** Tr. Am. Acad. Ophth. **63**:79-88, Jan.-Feb., 1959.

Approximately 400,000 persons in the United States have a visual acuity between 3/200 and 20/60. Of this number, perhaps 50 percent should have lenses prescribed and 70 percent of them will use the lenses successfully. The authors feel that 80 percent of patients with low vision can be prescribed for without special equipment. Various optical aids are described such as high plus lenses, projection devices, pinhole spectacles, contact lenses, and Galilean telescopes. The patient must be intelligent and adaptable and must desire this special help. (2 figures)

Harry Horwich.

François, J. and Verriest, G. **A study of congenital dyschromatopsias with symptoms intermediary to the classical dyschromatopsias and the typical achromatopsias.** Bull. Soc. belge d'opht. **119**: 430-444, 1958.

The patient, a 28-year-old man, demonstrated symptoms intermediate between the classical dyschromatopsia and the typical achromatopsia. He had a perception of red and blue separated by an extended neutral zone in the brown and purple with several lines of confusion parallel with this neutral axis. The chromatic differential thresholds were high except in the neutral zones, where they

were very low. The spectral, photopic visibility resembled protanopia. There was no receptor distribution pattern. The curves designating central visual acuity and illumination in red light were subnormal. The electrophysiologic examinations were normal except in the amplitude of the b-wave and the critical frequency in electro-retinographic fusion. Only 50 similar cases could be found in the literature and these were reviewed and tentatively classified. (1 figure, 1 table, 62 references)

Alice R. Deutsch.

Guzzinati, G. C. and Salvi, G. **The relationship between vertical disparity and stereopsis.** Boll. d'ocul. 37:498-507, July, 1958.

With the use of vertical prisms the authors were able to study the relationship between vertical diplopia and stereopsis. They found that as the vertical separation increased stereopsis decreased. In the presence of vertical diplopia no stereopsis was present. (4 figures, 2 tables, 25 references)

Joseph E. Alfano.

Jonkers, G. H. **A comparison of methods of determining stereoscopic vision.** Ophthalmologica 137:15-21, Jan., 1959.

In 73 normal young individuals the acuity of stereopsis was determined with 1. Hering's falling ball test, 2. a three-bar apparatus of the type of Howard-Dolman's, and 3. Verhoeff's apparatus. Statistical treatment of the data revealed no correlation between the results of the three methods. A high score with one method did not correlate significantly with a high score with any of the other methods. The author's conclusion is that the tests as done by him represented an inadequate indication of the acuity of stereoscopic vision. Some of the systematic errors inherent in the three methods could possibly be eliminated by repetition of the tests. A test arrangement might be designed that would more closely approach natural conditions. (3 figures, 5 references)

Peter C. Kronfeld.

Rendahl, Ilmari. **The electroretinogram of the light-adapted human eye. Clinical recording with the electronic flash as light stimulus.** Acta ophth. 36:900-916, 1958.

1. A study had earlier been made of the electroretinogram (ERG) on stimulation with single flashes of light of high intensity (electronic flash). An account is now given of the results of recordings from the light-adapted eye. A typical, diphasic ERG is obtained, with a moderate negative a-wave and a b-wave (x-wave) of about the same size. On the basis of its behaviour during dark adaptation, and in comparison with the ERG obtained on stimulation with slow flickering light, this is interpreted as a photopic ERG.

2. Examination of a patient with congenital night blindness (cone retina) elicited, on light adaptation, an electronic-flash ERG practically identical with that from the normal eye. On dark adaptation, the same ERG is obtained, which is compatible with the conception of a photopic ERG.

3. Recordings in a patient with total color blindness (rod retina) show, as expected, normal conditions on dark adaptation. On light adaptation, a reduction in size of the components is to be anticipated (bleaching of visual purple), but a shortening of the latencies occurs as well, so that in this case the electronic-flash ERG has the same appearance as that from the normal eye. Against the background of other electroretinographic studies, this is considered to be due chiefly to the fact that the cones suppress rod function in normal eyes, and the absence of the suppression in total color blindness is responsible for the short latencies. It is pointed out that this view has been put forward earlier by Bornschein and Goodman in a similar case.

4. On examination of a group of pa-

tients with eye diseases, chiefly circulatory disturbances of the retina, a pathologic electronic-flash ERG is obtained on light adaptation, with lower potentials but unchanged latencies. These variations are found to run parallel with the changes in the electronic-flash ERG on dark adaptation, which is therefore suggested to suffice for clinical purposes.

In a preliminary recording of the electronic-flash ERG in severe macular damage (one case) a normal tracing is obtained.

5. It is pointed out that, even if the electronic-flash ERG is regarded as a photopic ERG, the recordings in total color blindness show that it may be impossible, in practice, to infer the absence of cones from the retina on the basis of this tracing. (10 figures, 1 table, 41 references) Author's summary.

Sten, Stenius. **Presbyopia and its correction.** Acta ophth. Suppl. 47:1958.

This monograph deals in great detail with the problem of presbyopia and its physiologic basis. It contains a wealth of material. The author believes that the near-correction for presbyopia should place the binocular near point 0.3077 m. from the eye. The accommodation is limited by the increasing rigidity of the lens. Accommodation is never completely lost; no higher correction than 2.5D is ever required.

Presbyopic complaints do not occur before the binocular near point has moved farther than 30 cm. from the eye. It is not always necessary to expect reading of the smallest type. Illumination and stature of the patient influence the "empiric reading distance."

The binocular near point, when determined by the author's method, shows constant values. The correction of presbyopia according to the "empiric reading distance" is usually satisfactory but a determination of the binocular near point and its placement at a distance of 31 cm. from the eye is more successful. The strength of the reading glasses can, at least in younger patients, vary within certain limits without discomfort. Complaints about glasses are usually due to unsatisfactory fitting. A "wrong" strength of the glasses merely results in imperfect visual acuity within the acquired working distance. (32 figures, 32 tables, 79 references) John J. Stern.

Tavolara, L. **Improvement in visual acuity in strabismus associated with amblyopia.** Boll. d'ocul. 37:508-517, July, 1958.

The author evaluates the visual acuity in 120 patients with amblyopia who had been treated by occlusion of the fixing eye. He found that the child is able to distinguish symbols with greater accuracy when they are isolated than he can when they are placed close together. He feels that the designer of charts used for the testing of visual acuity in amblyopic children should take this into consideration. (3 figures, 14 references)

Joseph E. Alfano.

Urist, Martin J. **Afterimages and ocular muscle proprioception.** A.M.A. Arch. Ophth. 61:230-232, Feb., 1959.

It was noted that afterimages produced in normal subjects moved in the same direction as active movements of the head or eyes, even when the eyes were closed. However, there was no movement of the afterimages when the eyes were moved passively. When nystagmus was induced by the Bárány chair or the opticokinetic drum the afterimages were projected to the side of the slow phase of the nystagmus, but the observers did not notice any back-and-forth movement of the images. It was also noted that upon convergence the images became smaller and upon di-

vergence they became larger. This occurred with both open and closed eyes. These experiments are interpreted as producing further evidence that afterimages have a cerebral, not a retinal, origin; and that their projection is determined by ocular muscle proprioception. (4 references) William S. Hagler.

Verhoeff, F. H. **The normal frontal plane horopter discovered by means of a new device, the horopter finder.** A.M.A. Arch. Ophth. 61:298-307, Feb., 1959.

Verhoeff describes a new devices, the horopter finder, which locates the midline plane horopter as well as the sum of the alpha angles. This device reveals that each alpha angle is normally about 5.5 degrees and that they produce a frontal plane horopter at about 32 cm. from the eyes, that is, the frontal plane horopter occurs at a midline bifixation point corresponding to a convergence of twice the alpha angle. All frontal planes farther away appear elliptically concave, and all those nearer, elliptically convex. This device is also useful in determining the acuity of stereopsis. (2 figures, 2 references)

William S. Hagler.

Weigelin, E. and Neumann, G. **Statistical studies of the clinical course of high myopia.** Ophthalmologica 137:1-14, Jan., 1959.

The relationship between age and corrected visual acuity was determined from observations on 205 eyes with myopia ranging from 10 to 30 diopters (cases of retinal detachment were excluded). Most of the patients were followed for short periods only. Long-term observations were not available. The mean visual acuity of the high myopes was about .3 up to the age of 40, .25 from there to the age of 60, and about .15 from there on. The latter value is considered as visual disability, corresponding to industrial blindness in the U.S.A. Manual labor seemed to accelerate the deterioration of vision. (4 figures, 4 tables, 4 references)

Peter C. Kronfeld.

Zanen, J. and Meunier, A. **Disparity in the chromatic perception of identical twins.** Bull. Soc. belge d'opht. 119:444-450, 1958.

Disparity in color perception of identical twins is interesting not only from the viewpoint of clinical interpretation of the capability to respond to specific color stimulation but also from the viewpoint of genetics.

One of the female twins under investigation was phenotypically normal while the other demonstrated mild dyschromatopsia by erroneous reading of the pseudo-isochromatic tables of Ishihara and by correct reading of the plates of Bostroem and Kugelzerg. Determination of the threshold values revealed an elevation in the blue-green range. The inequality of the dyschromatopsia in the twins was mild. Dyschromatopsias in twins are very rare; one pair of deuteranopic twins occurs in 1,800,000 births and one pair of genuine protanopic twins among 80,000,000 births. The significance of such studies lies not only in the observations of facts in heredity. Increasing knowledge of physiopathology may encourage recognition of other factors dependent on genotypes and distinguish them from other possible contributing factors. (2 figures, 1 reference)

Alice R. Deutsch.

5

DIAGNOSIS AND THERAPY

Al Saadi, A. H. and Stucchi, C. **Fever therapy in ophthalmology.** Ophthalmologica 137:51-61, Jan., 1959.

The preparation used by the authors was Pyrexal (Wander), the active principle of which is a lipopolysaccharide ex-

tracted from an organism of the Salmonella group. The usual initial dose is 0.1 microgram given intravenously. Repeated febrile responses of approximately equal magnitude are obtained by increases in dosage of 0.1 microgram. The results in 60 cases with various ophthalmologic conditions are reported. (6 tables, 15 references) Peter C. Kronfeld.

Blum, F. G., Gates, L. K. and James, B. R. **How important are visual fields?** A.M.A. Arch. Ophth. **61**:1-8, Jan., 1959.

In a survey of 1,892 consecutive paired fields, it was noted that the peripheral fields rarely demonstrated a defect that the central fields failed to show. Only in ideal and rare circumstances is it possible for a field to be charted with true scientific accuracy. The accuracy of the tangent screen is limited to 35 to 38 degrees from the fixation point. Probably 95 percent of all ophthalmoneurologic lesions are quantitatively discoverable within this area.

There are definite quantitative criteria for evaluating a normal central field. This is not true of the peripheral field. Here shape, rather than size, is more important for diagnosis. Uniform depression suggests a functional etiology.

"The abolition of perimetry is not advocated; however the real value of routine use of peripheral field taking (in clinical practice) is questioned." (7 references) Irwin E. Gaynon.

Charvarria Iriarte, Ricardo. **Ophthalmologic application of Wood's light.** Arch. Soc. oftal. hispano-am. **18**:1057-1063, Oct., 1958.

The physical properties of ultraviolet light, as used in Wood's light, are described, and its application in ophthalmology reviewed. Eleven cases in which it was used therapeutically are briefly mentioned. (1 figure, 10 references) Ray K. Daily.

Eggers, Harry. **The Maddox-rod phenomenon.** A.M.A. Arch. Ophth. **61**:246-247, Feb., 1959.

The author gives a brief description of the optics involved in the Maddox-rod phenomenon and illustrates this with a schematic drawing in perspective. (1 figure, 2 references) William S. Hagler.

Kleefeld, G. **Eye examination under a focal beam filtered by cobalt blue glass.** Bull. Soc. belge d'opht. **119**:407-418, 1958.

The fluorescence of the iris pigments, of the pigment in conjunctival melanosis, of the blood, of the fundus and of the lens were noted when these structures were viewed through a cobalt filter in front of a light bulb with a Tungsten filament. A very strong light source, focal illumination and a specially constructed optical system for the projection of the image of the filament are necessary. The qualities of the various filters, their transmission curves and the effects of diffuse and focal illumination as well as the various methods of examination are discussed. (3 figures) Alice R. Deutsch.

Lubkin, V. and Hughes, W. L. **The fornix conformer.** A.M.A. Arch. Ophth. **61**:248, Feb., 1959.

Two types of plastic crescent-shaped fornix conformers developed by the authors are described. These are especially valuable in reconstructing fornices in those cases in which the presence of a seeing eye precludes the use of a standard complete conformer. They contain apertures so that they may be sutured into either the upper or lower fornix. (3 figures) William S. Hagler.

Portolano, F. **General anesthesia for ophthalmic surgery of infants.** Arch. di ottal. **62**:477-495, Nov.-Dec., 1958.

The author discusses at length various preoperative medications, types of anes-

thetic agent, and postoperative measures. He states that of 650 patients 1 percent had respiratory depressions due to barbiturates and only 1.5 percent had postoperative vomiting. If the muscle cases are excluded, the incidence of postoperative vomiting is only 0.3 percent. (23 references) Paul W. Miles.

Sommer, Gerd. **Protective measures for a keratoplasty in aphakic eyes.** Klin. Monatsbl. f. Augenh. **134**:72-78, 1959.

The author introduces a spatula-like instrument into the anterior chamber at the limbus to protect the vitreous. A preplaced suture is used. (5 figures, 15 references) Frederick C. Blodi.

Weekers, R. and Lavergne, G. **Clinical application of static perimetry.** Bull. Soc. belge d'opht. **119**:418-430, 1958.

Static perimetry as introduced by Harms relies on the increasing luminescence and progressive contrast of a fixed target of given size. At present the perimeter of Goldman with the new projection equipment of Haag & Streit is the instrument of choice. As a procedure of great accuracy it is a desirable complement to the conventional perimetry. It reveals deficits in the fields not ascertained by the customary modes of investigation. In the follow-up and early diagnosis of glaucoma it discloses changes in the size and density of scotomas better then any other method. It is equally valuable in neuro-ophthalmology by early detection of beginning hemianopsia, visual deficits and their eventual progress. Charts of kinetic and static visual fields demonstrate concordance in the findings with these two techniques in most cases. (10 figures, 18 references)

Alice R. Deutsch.

6
OCULAR MOTILITY

D'Arrigo, P. and Pandolfo, G. A. **Clinical relief by therapy with Reserpine and methylphenidate hydrochloride in insufficiency of convergence.** Arch. di ottal. **62**:513-522, Nov.-Dec., 1958.

Insufficiency of convergence is reviewed and classified. The authors found it in 2.8 percent of office patients. In a series of 35 patients in which a definite etiology could not be found, 60 percent obtained relief by use of Reserpine with Ritalin. There was complete relief in a few, but many patients required additional orthoptic training. The patients were between 14 and 35 years of age. (56 references) Paul W. Miles.

Konstas, K. A. **Convergence excess.** Ophthalmologica **137**:22-35, Jan., 1959.

The term convergence excess is applied to a disturbance of ocular motility characterized by 1. occurrence in slightly hyperopic grade school children, 2. almost normal motor conditions by the ordinary tests, and 3. a gradually but steadily increasing esophoria elicited by prolonged close work and culminating in a severe spasm of convergence and accommodation. The subjective symptoms are those of asthenopia with or without diplopia. The objective symptoms are disclosed by dynamic retinoscopy and phoria measurements during close work. The cause of the anomaly is sought in a hypertonicity or hyperexcitability of the mesancephalic convergence center. The treatment consists of correction of the existing hyperopia, abstention from the practice of voluntary convergence, general hygienic measures, and psychotherapy. The measures mentioned last are considered most important by the author. (1 figure, 12 references) Peter C. Kronfeld.

Lijo Pavia, J. and Marcone, G. **Voluntary unilateral divergence.** Rev. oto-neuro-oftal. **33**:76-79, Sept.-Dec., 1958.

In support of the theory of an active divergence center, the authors present the clinical observations on a patient with voluntary unilateral divergence of the

right eye, up to 68 degrees as measured with the synoptophore. The patient had normal findings in a routine examination and had very good convergence but could, at will, diverge the right eye and keep it in this position until he was asked to bring it back to normal position. (3 figures, 12 references) Walter Mayer.

Marg, E., Jampolsky, A. and Tamler, E. **Elements of human extraocular electromyography.** A.M.A. Arch. Ophth. **61**:258-269, Feb., 1959.

The essential elements of the human electromyograph of the extraocular muscles are presented. The basic equipment used by the authors is described and illustrated. At present extraocular electromyography is chiefly valuable in research although it has some clinical usefulness in neuro-ophthalmologic diagnosis and prognosis. (20 figures, 45 references)
William S. Hagler.

Nicolaissen, B. and Brodal, A. **Chronic progressive external ophthalmoplegia.** A.M.A. Arch. Ophth. **61**:202-210, Feb., 1959.

A case of chronic progressive ophthalmoplegia in a 53-year-old woman is described. She had steady progression of ptosis and external ophthalmoplegia over the past seven years. Although she complained of weakness of her neck and legs physical examination of these structures was normal. The urinary excretion of creatine and creatinine was within normal limits.

Biopsy of the right lateral rectus muscle showed marked increase of connective tissue, even within the primary muscle bundles, as well as marked atrophy of the muscle fibers. All stages of atrophy were present but there was no grouping of fibers in the same stage of atrophy as would be expected in atrophy resulting from lesions of the peripheral motor neurons. Biopsy of the sternocleidomastoid muscle showed similar but less marked histologic changes.

These findings are similar to those described in cases of muscular dystrophy and it is therefore felt that at least some cases of progressive chronic external ophthalmoplegia represent simply a particular form of muscular dystrophy. Many more cases will have to be described before it can be determined what percentage of cases of chronic external ophthalmoplegia will fit into this category. (2 figures, 17 references) William S. Hagler.

Rizzo, P. and Pallier, L. **Components of ocular movements during television and cinema viewing.** Boll. d'ocul. **37**:565-597, Aug., 1958.

The authors studied the ocular movement in patients who were viewing television and the cinema. The research was conducted by means of a photographic film which registered the movements on the ophthalmograph. The distance of the viewing screen varied from one to five meters, in both the primary and the oblique position. The analysis of films taken revealed the following principal movements: saccadic, slow deviation movements, continuous movements with a fixational pause, fusional disjunctive movements, wider adjustment movements and some vertical and circular movements. Numerically the frequency of the movements, particularly the saccadic ones, increased in the near and oblique positions whereas the amplitude of the movements decreased with the increase of the distance and in the oblique positions. A comparison of the movements recorded while watching television did not differ substantially from those of the cinema, except for a smaller amplitude of the movements during observation of the latter. (51 figures, 2 tables, 23 references)
Joseph E. Alfano.

Snydacker, Daniel. **Diabetic neuropathy as a cause of extraocular muscle palsy.** Tr. Am. Acad. Ophth. **62**:704-708, Sept.-Oct., 1958.

Six cases of extraocular muscle palsy due to diabetic neuropathy are presented. In four cases the sixth nerve was affected, in one the entire third nerve, and in one the fourth nerve. The typical course is described: sudden onset of diplopia preceded by vague prodromal feelings and followed by spontaneous recovery in three weeks to five months. (14 references)

Harry Horwich.

Stephens, J., Hoover, M. L. and Denst, J. **On familial ataxia, neural amyotrophy, and their association with progressive external ophthalmoplegia.** Brain **81**:556-566, 1958.

A family is described in which four members of one generation showed features of Friedreich's ataxia and Charcot-Marie-Tooth disease associated with external ophthalmoplegia, and 19 members of subsequent generations had formes frustes of these diseases. Postmortem examination of one case showed the ophthalmoplegia to be due to a primary ocular myopathy. The spinal cord findings are compared with those in the two previously autopsied cases of combined spinal ataxia and neural amyotrophy. It is concluded that in this family the chance association of a neuropathy and a myopathy is unlikely, and the evidence is consistent with a single genetic abnormality. (10 figures, 9 photomicrographs, 40 references)

Authors' summary.

Tamler, E., Marg, E. and Jampolsky, A. **An electromyographic study of coactivity of human extraocular muscles in following movements.** A.M.A. Arch. Ophth. **61**:270-273, Feb., 1959.

Multichannel electromyography of human extraocular muscles was performed to determine if cocontraction of the auxiliary muscles occurred during slow horizontal and vertical following movements of the eyes through the primary position. It was found that there was little or no increased coactivity of the auxiliary muscles during these movements. It is therefore felt that the primary position tonus alone of the auxiliary muscles is sufficient to steady the eye and to prevent torsion during following movements. 5 figures, 10 references) William S. Hagler.

7

CONJUNCTIVA, CORNEA, SCLERA

Arques, E. **Secondary filamentous keratitis.** Arch. Soc. oftal. hispano-am. **18**:847-848, Aug., 1958.

The author reports a case of filamentous keratitis as a postoperative complication of an uncomplicated cataract extraction 19 days after the operation. After failing to respond to the usual therapeutic measures the patient improved rapidly on the administration of Aminomade. The pathogenesis of this rare and disagreeable complication is not clear. Ray K. Daily.

Avello, Valcarce. **Keratoplasty in the treatment of keratoconus.** Arch. Soc. oftal. hispano-am. **18**:874-883, Aug., 1958.

Two cases are reported. The graft was square in one case and round in the other. In both cases there was a tendency to protusion of the cornea, which subsided after ten days of a pressure bandage. Both patients developed disease of the graft three months postoperatively. In one case an infected ethmoid was diagnosed, and after an ethmoidectomy the transplant rapidly cleared. In the second case the rhinological examination was negative, and the cornea cleared within a week under general and local corticosteroid therapy. The author stresses the importance of a large graft in cases of keratoconus and points out that in these cases

Castroviejo's square graft is advantageous. Emphasis is placed on gentle technique, sharp instruments, particularly trephines and needles, and firm closure of the wound with numerous sutures. The closure should be tested by introduction of air into the anterior chamber; failure of the air to stay in is an indication for more sutures. Postoperatively, miotics at first, and then weak mydriatics, alternated with miotics, should keep the iris mobile. (7 figures, 4 references) Ray K. Daily.

Christensen, Leonard. **Cornea and sclera, annual review.** A.M.A. Arch. Ophth. **61**:308-333, Feb., 1959.

The author comprehensively and systematically reviews 304 articles written during the last year on the cornea and sclera. (304 references)

William S. Hagler.

Frezzotti, R. **Adenovirus type 8 (APC8) and epidemic keratoconjunctivitis.** Boll. d'ocul. **37**:481-497, July, 1958.

The author presents his findings in an epidemic of keratoconjunctivitis. He was able to isolate the adenovirus type 8. The condition began as a severe conjunctivitis and in 92 percent of the patients a punctate keratitis also appeared. The author reproduced the condition in a human eye by inoculation with the virus which had been isolated from another patient. He presents the histologic findings. (14 figures, 19 references) Joseph E. Alfano.

Kutschera, E. **The surgical treatment of keratoconus.** Klin. Monatsbl. f. Augenh. **134**:78-82, 1959.

Out of 31 grafts 28 remained clear and in 21 of the patients the vision was 6/9 or better. Keratoplasty is therefore the operation of choice for severe cases of keratoconus. It is far superior to the old Sato method of incising the posterior corneal surface. (1 figure, 9 references)

Frederick C. Blodi.

Menna, F. **Action of heparin after caustic burns of the cornea by acids and alkalis.** Arch. di. ottal. **62**:523-543, Nov.-Dec., 1958.

The author presents experimental and clinical evidence that a collyrium containing heparin is helpful in chemical burns of the cornea caused by acid or alkali. Histologic studies on guinea pigs suggest that corneal change is related to loss of polysaccharides. Heparin is said to act by preserving the polysaccharide. It is also believed to favorably affect fibroplastin, vasodilation and anti-hyaluronidase, and to be anti-anaphylactic, anti-bacterial and lipotropic. In a series of 27 patients, the final visual acuity appeared to be better than expected after treatment with heparin topically. (17 figures, 1 table, 23 references) Paul W. Miles.

Paliaga, G. P. **Intraepithelial vesicular keratitis caused by solvents.** Boll. d'ocul. **37**:624-635, Aug., 1958.

The author reviews the literature of corneal epithelial lesions produced by the exposure to the solvents of nitrocellulose. The disease occurs frequently in workers handling varnishes containing nitrocellulose. The symptoms vary from a slight foreign-body sensation to a severe pain and photophobia. The lesion produced is that of an intraepithelial vesicle, and it responds well to the elimination of the irritant and to the topical application of hydrocortisone. (1 figure, 9 references)

Joseph E. Alfano.

Quinn, F. B., Jr. and Falls, H. F. **Cogan's syndrome: case report and a review of etiologic concepts.** Tr. Am. Acad. Ophth. **62**:716-721, Sept.-Oct., 1958.

A case of Cogan's syndrome (nonsyphilitic interstitial keratitis with vestibuloauditory dysfunction) is described. The patient was 60 years old (unlike most reported cases), was totally deaf, did not respond to maximal caloric vestibular

stimulation, and had a visual acuity of finger counting in each eye.

The many conditions which have been implicated in this syndrome are listed. Apparently there is a relationship to certain hypersensitive states. (17 references)

Harry Horwich.

Sedan, Jean. **Application of iodine and its supplementation by intracorneal neurotomy in dendritic keratitis.** Arch. Soc. oftal. hispano-am. **18**:844-846, Aug., 1958.

After trying the various remedies which have been proposed for the treatment of dendritic keratitis in the course of many years, Sedan concluded that cauterization of the corneal surface with iodine is the therapy of choice. For the last two years he improved his results by using a procedure devised by Pierre Guillot, who removes with a trephine and dissection a lamellar segment of the cornea one third its thickness including the lesions and follows this by the application of iodine. The result is a rapid relief of pain and a significantly accelerated cicatrization. Corneal sensitivity is restored more rapidly after this combined method of therapy than after iodine cauterization alone.

Ray K. Daily.

Segal, P. and Waniewski, E. **Rare complications of corneal and limbal injuries.** Klin. Monatsbl. f. Augenh. **134**:93-97, 1959.

A nine-year-old boy was injured by a knife at the limbus. A few weeks later a cyst-like structure grew at the site of injury. It was excised and histologic examination revealed a granuloma. (5 figures, 7 references) Frederick C. Blodi.

8

UVEA, SYMPATHETIC DISEASE, AQUEOUS

Braley, Alson E. **A case of Behçet's disease.** Tr. Am. Acad. Ophth. **62**:712-715, Sept.-Oct., 1958.

Hypopyon iritis in a 46-year-old man is described. The third attack left the eye blind, and only then did the patient complain of a sore in his mouth. He then had repeated attacks of aphthous stomatitis but never developed genital lesions. The painful eye was finally enucleated, and foci of round cells were found in the iris, ciliary body, anterior segment of the choroid, retina, and one of the extraocular muscles. The retina was completely detached and the lens capsule had ruptured, possibly iatrogenically. (3 figures, 3 references) Harry Horwich.

Coles, R. S. and Nathaniel, A. **The role of streptococcus in the pathogenesis of anterior uveitis.** A.M.A. Arch. Ophth. **61**:45-49, Jan., 1959.

In this study the authors have failed to find the correlation between anterior and posterior uveitis, and the antistreptolysin O titer. The basis for treating patients with anterior uveitis with intravenous stock vaccines is not yet fully established. (4 figures, 13 references)

Irwin E. Gaynon.

Contardo, R. **Uveitis.** Arch. chil. de oftal. **15**:16-36, Jan.-June, 1958.

The author gives an extensive summary of our knowledge of uveitis, granulomatous and nongranulomatous. He reviews the etiologic agents and therapeutic measures which have been considered. (2 tables, 84 references)

Walter Mayer.

Edwards, J. E. and Erdbrink, W. L. **Practical management of granulomatous chorioretinitis.** A.M.A. Arch. Ophth. **61**: 226-229, Feb., 1959.

The authors review their cases of granulomatous uveitis seen during 26 months. Since the Feldman-Sabin dye test for toxoplasmosis is not readily available they stress the importance of skin tests for toxoplasmosis as well as for tuberculosis.

The authors made a presumptive diagnosis of toxoplasmosis whenever there was a positive toxoplasmin skin test, negative PPD skin test, and negative chest X-ray findings. Tuberculosis was presumed to be the cause whenever there was a history of tuberculosis, X-ray evidence of healed or active tuberculosis, or a positive PPD #1 skin test.

In this series, 32 patients were given a presumptive diagnosis of toxoplasmosis and treated with pyrimethamine (Daraprim) and sulfadiazine for four to six weeks as a therapeutic trial. Steroids were used concomitantly in all patients with macular or paramacular lesions; 26 of them were considered to have excellent therapeutic results and only one showed a hematologic reaction which cleared rapidly with ACTH. There were four patients who had an initial diagnosis of tuberculous chorioretinitis and three of these showed excellent results with streptomycin and isoniazid. It is felt that any patient in whom an initial presumptive diagnosis of toxoplasmosis is made and who fails to show unequivocal response to therapy with Daraprim and sulfadiazine within one week should then be given a therapeutic trial with streptomycin and isoniazid. The authors had six patients in this group, four of whom showed excellent response to the antituberculous therapy. (3 tables, 4 references)

William S. Hagler.

Keerl, G. **Essential iris atrophy with macular changes.** Klin. Monatsbl. f. Augenh. **134**:54-65, 1959.

In a 45-year-old man with bilateral iris atrophy in the shape of a coloboma downward there were pigmentary changes in both macular areas. Similar cases have been reported in the literature and it is assumed that a common vascular factor in the ciliary arteries produces both conditions. (11 figures, 14 references)

Frederick C. Blodi.

Schlaegel, T. F. Jr., **Granulomatous uveitis: an etiologic survey of 100 cases.** Tr. Am. Acad. Ophth. **62**:813-825, Nov.-Dec., 1958.

In 18 cases only the anterior segment was inflamed, in 21 only the posterior segment, and in 60 percent primarily the posterior segment. An attempt is made to derive conclusions from correlation of the various findings, skin tests, laboratory tests, and so forth. Unfortunately so many positive responses occur that it is difficult to assess their value. Two therapeutic tests are of value: penicillin for syphilis, and isoniazid for tuberculosis. Daraprim is of no value as a therapeutic test for toxoplasmosis. Good evidence of an etiologic contact is a flare up of uveitis after a skin test. In only 17 percent of cases was there good evidence for making a probable diagnosis.

When divided into possible, probable and proved, the 100 cases were divided into toxoplasmosis, 30 percent; tuberculosis, 21 percent; heterochromic cyclitis, 3 percent; syphilis, 3 percent; sarcoid, 2 percent; and brucellosis, histoplasmosis, sympathetic ophthalmia and hookworm, 1 percent each; and undiagnosed, 28 percent. (1 figure, 9 tables, 39 references)

Harry Horwich.

9

GLAUCOMA AND OCULAR TENSION

Campbell, C. J. and Rittler, M. C. **The diagnostic value of flicker perimetry in chronic simple glaucoma.** Tr. Am. Acad. Ophth. **63**:89-98, Jan.-Feb., 1959.

Normal flicker values in 27 loci for a 1.5-degree stimulus have been mapped out. The test must be done quickly to prevent local adaptation which may appear in less than 10 seconds. The test object must be maintained at the locus for the test and is not moved like a conventional target. Miotics must be discontinued 48 hours prior to testing, as pupil size may affect

the CFF. Testing takes 20 minutes and is considered easier than standard campimetry.

In 92 normal eyes, 23 glaucomatous eyes without field defects, and 12 eyes with definite field defects flicker perimetry was done. Of the group with no field defect 83 percent showed a pathologic flicker response. In the group with field defects all subjects showed a pathologic flicker response. This is considered to be a delicate refinement for confirming the diagnosis of glaucoma in suspected cases. (10 figures, 3 tables, 4 references)

Harry Horwich.

Duke-Elder, Sir Stewart. **The nature of primary glaucoma.** Ann. d'ocul. 192:26-51, Jan., 1959.

This article is divided into two portions. In the first a review of the physiology of the formation of aqueous is reviewed. The author elaborates his thesis that the intraocular pressure is under the control of the central nervous system with a center for this control somewhere in the diencephalon. He illustrates this thesis with examples of the effect of emotion on intraocular pressure, the effect of changes in one eye on the pressure in the other and the abnormal EEG findings in many patients with simple glaucoma.

In the second part the complex of diseases known as "simple glaucoma" is considered. Open-angle glaucoma is discussed first, and in this disease there are three findings of importance: 1. an elevation of tension, 2. cupping of the optic nerve, and 3. loss of visual field. Although the elevated pressure plays a part in producing the other two findings, in all probability this is not the underlying difficulty. Without doubt there is some interference with the nutrition of the optic nerve which gives rise to the atrophy and visual field changes characteristic of the disease. The author points out that these occur commonly in the absence of elevated pressure and also even after a surgical lowering of the intraocular pressure. He further states that the disease processes may be limited to the anterior segment, in which case there is elevated pressure without field loss or optic nerve damage, or it may be limited to the posterior segment, in which case the pressure may be entirely normal yet vision deteriorates rapidly.

The author pays his respect to the mechanical theory of closed-angle glaucoma, but feels that this is not the whole explanation; basically there is a vasomotor instability that predisposes the eye to an attack of acute closed-angle glaucoma. (25 references) David Shoch.

Flocks, Milton A. **The pathology of the trabecular meshwork in primary open-angle glaucoma.** Tr. Am Acad. Ophth. 62:556-577, July-Aug., 1958.

The trabeculae of 16 eyes with primary open-angle glaucoma, and 11 eyes with secondary glaucoma of various types were studied in transverse, meridional, and serial tangential sections. Masson's trichrome, periodic acid-Schiff, Verhoeff's elastic tissue, Mollier's elastic, and ordinary hematoxylin and eosin techniques were used.

Degeneration of the trabecular meshwork was very marked in certain meridians, yet could be absent in other meridians. The changes were greatest in the external part of the meshwork, or the inner wall of Schlemm's canal, and consisted of narrowing and partial obliteration of Schlemm's canal, a thickening and foamy appearance of the tissue beneath, an increase in fibroblasts, narrowing of the interlamellar spaces, fibrosis and adhesions in the canal, proliferation of endothelium in the canal, vascularization, thickening of the trabecular beams with increased collagen content, hyalinization of the meshwork, and an increase in pigment. Comparison with normal eyes suggested that the changes in the trabecular

meshwork are secondary to the elevated pressure which is probably secondary to failure of the pressure regulating mechanism. The author feels that people with primary open-angle glaucoma have vulnerable trabeculae, possibly inherited. (14 figures, 32 references)

Harry Horwich.

Gloster, J. and Perkins, E. S. **Distensibility of the human eye.** Brit. J. Ophth. **43**:97-101, Feb., 1959.

The coefficient of ocular rigidity, K, decreases as the intraocular pressure increases. At an intraocular pressure of 25 cm. of saline the value of K varied from 0.012 to 0.027 in a study of eleven eyes. Variations of K will have considerable effect upon determination of the coefficient of facility of outflow, C. (3 figures, 1 table, 8 references) Irwin E. Gaynon.

Heinrich, P. **Tonographic findings after glaucoma operations.** Ophthalmologica **137**:45-51, Jan., 1959.

Tonographic measurements were made with a mechanical tonometer, before as well as two to three weeks and four to six months after glaucoma operations. For the conversion of the tonometric readings into volume and pressure units the scale of 1954 was used. Flow rates were calculated by assigning a value of 4 mm. to the episcleral venous pressure.

After iris inclusion and corneosclerectomy operations there was a good correlation between ocular tension and facility of outflow. Normalization of tension was in the majority of cases associated with improved outflow, and non-normalization of tension with unimproved outflow. These relationships were also found after cyclodialyses and peripheral iridectomy. Most significant was the finding that in eight out of 11 cases of continued visual field deterioration, in the face of apparently normal ocular tension after surgery, the facility of outflow was found to decrease further.

Normalization of ocular tension after cyclodiathermy was accomplished in a significant number of cases without a corresponding improvement of outflow. The author found tonography definitely helpful in the evaluation of the results of glaucoma operations. (1 table, 30 references)

Peter C. Kronfeld.

Jackson, C. R. S. **Standardized X-tonometers.** Brit J. Ophth. **43**:102-106, Feb., 1959.

In 1927 Schiøtz described his weightless tonometer which has a convex plunger. This instrument is very popular in the United Kingdom and Scandinavia. A chart which facilitates the conversion of scale readings into intraocular pressure in terms of mm. of Hg, has been correlated with the weighted American type. (3 figures, 3 tables, 5 references)

Irwin E. Gaynon.

Magitot, A. **The role of water metabolism in normal and pathological ophthalmotonus.** Ann d'ocul. **192**:9-25, Jan., 1959.

Magitot feels that mechanical interpretation of simple glaucoma is inadequate to explain the various manifestations of this disease. He feels that simple glaucoma is a disease of water metabolism and is primarily due to edema occurring within the globe secondary to vascular changes such as necrosis and occlusion of small nutrient vessels of the optic nerve, choroid, retina and iris. He uses many examples from general pathology to illustrate this point and feels that basically there may be a lesion in the hypothalamus which plays an important part in regulating the water metabolism of the globe.

Davis Shoch.

Nemetz, U. R. and Papapanos, G. **Operations in patients with glaucoma and**

severely constricted fields. Klin. Monatsbl. f. Augenh. **134**:83-88, 1959.

Among 276 glaucoma patients in whom the visual field was reduced to 5 degrees or less in at least one segment there were 184 in whom vision remained essentially unchanged after the operation. If the central vision was 6/60 or less the probability of severe postoperative deterioration was high. (4 figures, 2 references)

Frederic C. Blodi.

Ruiz Barranco, F. and Montero Marchena, J. **The effect of hyaluronidase on the tension of glaucomatous eyes.** Arch. Soc. oftal. hispano-am. **18**:848-867, Aug., 1958.

A review of the literature is followed by a tabulated report of the author's investigation on the effect of subconjunctival injection of hyaluronidase on the ocular tension of glaucomatous eyes. Ten units dissolved in ½ cc. of physiologic saline was injected close to the limbus in the superior region of the globe. Tonography was performed immediately before and 24 hours after the injection. The material comprised 75 eyes, 59 of congestive glaucoma, and 16 of noncongestive glaucoma. In the majority of cases the ocular tension fell to 15 mm. Hg within 24 hours after the injection. The effect increases up to 12 to 15 hours after injection, remains static 30 to 36 hours, and then gradually diminishes, to disappear between 48 and 72 hours. Tonography demonstrated practically in every case that the resistance to outflow was lowered, the degree depending on the initial rise in resistance and on the state of the organic lesions. The effect is least manifest in early cases, in which a function-regulating mechanism probably compensates for the action of the drug on the ocular tension, and in cases in which the eye has anterior synechia and an obliterated angle of the anterior chamber, with absence of substances sensitive to the drug. The effect on the facility of outflow was not constant, although in the majority of cases it was increased. There was no effect in far advanced cases, in acute attacks, and in postoperative cases. In some eyes with a horizontal tension curve the tension was somewhat reduced; this is attributed to facilitation in the blood-aqueous exchange, since the angle of the anterior chamber could not be affected. The data indicate that hyaluronidase acts on the tissues in the angle of the anterior chamber and on the blood-aqueous exchange of the glaucomatous eye. The possibility of an effect on the vitreous is discussed, but in this study could not be determined.

It is believed that the existence of a substance in the angle of the anterior chamber sensitive to the action of hyaluronidase indicates the presence in the eye of a regulating mechanism for the adaptation of resistance to outflow; the extracellular situation of this substance accounts for the rapid response to afferent impulses. Vigorous massage diminishes the resistance to outflow temporarily. The reformation of this substance may come through a secretion of the ciliary body or it may be produced in situ.

It is concluded that diagnostically or therapeutically the procedure is not significant. (3 tables, 12 references)

Ray K. Daily.

Sanna, Marcello. **The indications and limitations of surgery in cases of glaucoma with residual paracentral scotoma.** Boll. d'ocul. **37**:598-607, Aug., 1958.

Sanna emphasizes the prognostic importance of changes in the paracentral isopters of the visual field in patients with glaucoma. In 70 patients antiglaucoma surgery was followed by reduction of the central isopters but with little change in the peripheral ones. (10 figures, 1 table, 8 references)

Joseph E. Alfano.

Scheie, Harold G. **Peripheral iridectomy with scleral cautery for glaucoma.** A.M.A. Arch. Ophth. **61**:291-297, Feb., 1959.

Scheie reports the results of his fistulizing operation in 70 eyes. The operation consists of making a perpendicular ab externo incision 1 mm. behind the limbus under a large flap of conjunctiva and Tenon's capsule. The scleral wound edges are cauterized with a Hildreth cautery in order to make them retract and the wound to gape. A peripheral iridectomy is performed and the flap closed in two layers.

Of the 70 eyes reported, 28 had narrow angle glaucoma and 43 chronic simple glaucoma. The results in the narrow angle group were the best; 23 became normotensive, four hypotensive, and only one remained uncontrolled. In the chronic simple group, 25 became normotensive, 11 hypotensive, and six remained uncontrolled. The anterior chamber reformation was delayed one week or longer in 25 eyes, but in only one was air injection necessary. Hyphema occurred in eight eyes, but in none of these did it interfere with the outcome.

The chief advantages of this procedure are its safety and ease of performance. The danger of sympathetic ophthalmia should be less than with iridencleisis. Because the filtering bleb is usually thick-walled the author feels that the danger of late infection should be less than after trephination. This operation is said to be particularly suitable for neglected acute glaucoma since the cautery will reduce the tendency to bleed. (6 figures, 2 tables, 1 reference) William S. Hagler.

Scheie, Harold G. **Retraction of scleral wound edges as a fistulizing procedure for glaucoma.** Tr. Am. Acad. Ophth. **62**: 803-812, Nov.-Dec., 1958.

The details of this new procedure are clearly presented and illustrated. One creates a fistulous sclerotomy by cautery and incision about one millimeter posterior to the limbus. A peripheral iridectomy is performed and a well covered bleb is allowed to form. Data from 41 eyes are tabulated. In narrow-angle glaucoma there were no failures. However, in six eyes with chronic simple glaucoma the tension did not become normal. The procedure is easy and surprisingly atraumatic. (10 figures, 2 tables, 5 references) Harry Horwich.

Weekers, R. and Gustin, J. **Study of pupillary diameter in the dark-adapted eye in glaucoma.** Arch. d'opht. **18**:257-261, April-May, 1958.

Despite the concept of Loewenstein that alterations in the pupillary diameter can be attributed to derangement of a diencephalic nerve center, the authors conclude from their study as follows: 1. the pupillary diameter of the normal dark-adapted eye decreases with age; 2. the dark-adapted pupil is not modified in either open- or closed-angle glaucoma; and 3. prolonged use of miotics permanently alters iris structure and reduces pupillary diameter. (1 figure, 3 tables, 9 references) P. Thygeson.

10
CRYSTALLINE LENS

Arruga, H. **New procedures in cataract surgery.** Arch. Soc. oftal. hispano-am. **18**: 1073-1075, Nov., 1958.

The three procedures discussed and approved are 1. injection of air into the anterior chamber after the delivery of the lens, 2. irrigation of the anterior chamber with a solution of acecoline, 1:3000, to contract the pupil, and 3. the injection of chymotrypsine into the posterior chamber. Ray K. Daily.

Barraquer, J. and Boberg-Ans, J. **Cataract surgery.** Brit. J. Ophth. **43**:69-77, Feb., 1959.

The surgeon should sit comfortably at the head of the table. His elbows and

forearms should be supported by an arm rest. The lighting should be uniform and strong enough to show the smallest detail and not annoy the patient. A head lamp is used. Local anaesthesia of the cornea is obtained by the use of four percent cocaine and two percent tetracaine. Curare gives general relaxation, decrease of venous tension, depletion of the orbital veins and on opening the cornea, the lens moves backwards, the iris is unsupported and remains dilated. Suction drainage, used to evacuate fluids from the conjunctival sac, diminishes the risk of infection and prevents blood from being sucked into the anterior chamber.

A limbus-based flap is made. Corneoscleral sutures of silk dyed with two-percent methylene blue are placed at 12:00, 10:30, and 1:30-o'clock. The sutures are allowed to remain indefinitely. The cornea is lifted. The erisophake is applied to the front surface of the lens, as far as possible toward the lower border of the pupil. On contact, vacuum suction of 400 to 500 mm. Hg is applied. By turning the erisophake and continuing the rotation the lens is tumbled. The iris is replaced by means of a mohair brush. (10 figures, 17 references) Irwin E. Gaynon.

Costi, C. **Our first attempts with enzymatic zonulolysis.** Arch. Soc. oftal, hispano-am. **18**:1076-1084, Nov., 1958.

Fifty cases in which operation was done with the aid of chymotrypsin and 50 without this enzyme are compared as to the success of intracapsular extraction and loss of vitreous. The table shows 47 intracapsular extractions in the series with the enzyme and 43 without the enzyme. There was loss of vitreous in six cases in the enzyme series, and two in the series without the enzyme. The author concludes that chymotrypsin raises the percentage of intracapsular extractions, and also the percentage of vitreous loss. (1 table) Ray K. Daily

Eggers, C. **Our experience with Chandler's maneuver.** Arch. chil. de oftal. **15**: 5-15, Jan.-June, 1958.

The author reviews the procedures which have been designed to reduce the incidence of vitreous loss and other complications of cataract surgery. He feels that Chandler's maneuver, the application of pressure on the globe for five minutes after the retrobulbar bloc, is the greatest advance in lens surgery. This pressure must be made correctly and the eyes should be checked with a tonometer before and after the pressure is applied in order to make sure that a marked reduction in the ocular tension is obtained.

The author then describes his technique for lens extraction and presents tables to indicate the different tonometric values on patients before and after the Chandler pressure has been applied. (5 tables, 18 references) Walter Mayer.

Gartner, S. **Methods of inducing anesthesia and hypotony for cataract surgery.** A.M.A. Arch. Ophth. **61**:50-54, Jan., 1959.

A complete novocaine block of all the extraocular muscles lowers the ocular tension. Hyaluronidase increases the speed of diffusion of the anesthetic and also lowers the tension. The addition of epinephrine lowers tension in the eye by vascular effect. Finger pressure on the eyeball increases the rate of diffusion of the anesthetic solution. Pressure is applied until the ocular tension falls below 12 mm. Schiøtz. This usually takes three minutes and should be measured with a tonometer. Tetracaine and epinephrine added to the anesthetic solution will help prolong its effect. Irwin E. Gaynor.

Leibiger, W. **A family tree of patients with membranous cataract.** Klin. Monatsbl. f. Augenh. **134**:97-100, 1959.

Four children of seven siblings were affected. (1 figure, 13 references) Frederick C. Blodi.

Rigdon, R. H., Feldman, G. L., Ferguson, T. M., Reid, B. L. and Couch, J. R. **Cataracts produced by dinitrophenol.** A.M.A. Arch. Ophth. **61**:249-257, Feb., 1959.

Day-old chicks given dinitrophenol in their food developed lens opacities within two to four hours. These opactities began in the center and progressed within a period of six to eight hours until the entire lens became milky-white. These opacities spontaneously regressed upon removal of the drug. The older the chickens the lower the susceptibility to dinitrophenol. Chicks hatched from hens fed dinitrophenol were apparently normal and showed no macroscopic or microscopic evidence of lens opacities. However, if the drug was injected into the yolk sac of developing chick embryos, degeneration of the lens occurred in almost all cases. The mechanisms for these lens changes brought about by dinitrophenol is unknown but the changes in the lens are similar histologically to the lens degeneration seen in vitamin E-deficient turkey embryos. (10 figures, 28 references)

William S. Hagler.

Silvan, Fernando. **Observations and comments on cataract surgery.** Arch. Soc. oftal. hispano-am. **18**:1085-1095, Nov., 1958.

The author advocates the preoperative and postoperative use of antibiotics and stresses the importance of giving antibiotics in sufficiently large doses if they are to be effective. Ocular hypertension is obtained by the combination of light massage, hyaluronidase, diamox and pharmacodynamic potentialization. The author warns that hyaluronidase favors diffusion in the tissues, and should not be used in cases with suspicion of infection of conjunctiva or lacrimal passages. Diamox should not be used in patients with disturbances of the adrenocortical system, diabetes, and renal stones. A preliminary conjunctival flap of 4 to 5 mm. all around the keratotomy is advocated for the avoidance of epithelial invasion of the anterior chamber, and for the protection against infection. The author describes two new instruments: an inverse knife for making the keratotomy in the left eye with the right hand when the surgeon is seated behind the patient's head, and a suction apparatus with a foot control and a cable for the erisophake for the lens extraction. Three sclero-corneal sutures, and separate interrupted sutures for the conjunctival flap close the incision. The lens is delivered without tumbling. (7 figures, 6 references) Ray K. Daily.

Vellieux, M. and Le Breton Oliveau, G. **Cataracts in Africa.** Ann. d'ocul. **192**:52-70, Jan., 1959.

The authors did 355 cataract extractions at the Tropical African Institute at Bamako. Their particular interest lies in the occurrence of other diseases of the eye in this group of patients and many complicated cases are presented. Of the 355 patients 30 percent had an elevated tension. A similar percentage showed evidence of trachoma and 27 percent showed evidence of treponema infections. About 20 percent showed onchocerciasis and many patients showed more than one complication. As might be expected the incidence of complications was higher in this group of patients with other diseases of the eye. For example, in the group having only cataracts the incidence of vitreous loss was 6 percent, while in the group of complicated cases the incidence was 19 percent. (8 tables, 7 references) David Shoch.

Verdaguer J. **Luxated Margagni's cataract.** Arch. chil. de oftal. **15**:37-40, Jan.-June, 1958.

The author describes a patient with bilateral luxation into the vitreous of Morgagni's cataracts. The right eye became

violently inflamed about seven years after the luxation, but after a stormy course for several months, recovered completely without ever having had any posterior synechiae. The left eye, while responding very poorly to all types of anti-inflammatory measures, is now slowly recovering from its violent uveitis. The characteristics which suggest that the uveitis was brought about by the luxated Morgagni's cataract are 1. the marked depth of the anterior chamber, 2. the patent chamber angle, and 3. the total absence of fibrinogen in the aqueous. The latter accounts for the absence of posterior synechiae or pupillary membranes in spite of the violent uveitis and the remarkable conservation of the posterior structures of the eye. The only treatment which appeared to be somewhat effective was the retrobulbar injection of alcohol. Walter Mayer.

11

RETINA AND VITREOUS

Alagna, G. and D'Arrigo, P. **Storage of lipoid in the retina in essential hyperlipemia.** Arch, di ottal. 62:445-476, Nov.-Dec., 1958.

In a man, aged 49 years, who had a central scotoma in each eye, the vision was reduced to 20/100 and 20/70. He had xanthomatous lesions of the fingers, knees, buttocks, and in other regions, a blood cholesterol of 810 mg. percent and a total lipoid of 6970 mg. percent. In each macular region there were vitelliform lipoid deposits, the size of the disc, bulging forward about three diopters. After six months of a diet low in calories and fat but containing vitamins and lipotropic substances, his visual acuity improved in the left eye to 20/30. (9 figures, 71 references) Paul W. Miles.

Applemans, M., Michiels, J. and Doyen, N. **Pseudo-colobomatous chorioretinal dysplasia, associated with microgyria.** Bull. Soc. belge d'opht. 119:450-460, 1958.

Chorioretinal dysplasias with or without extraocular malformations are only rarely seen in adults because the cerebral hypoplasia and underdevelopment of the higher trophic centers in the brain lower the life expectancy of these subjects to only a few years.

The case history of a 23-year-old man with retinal dysplasia is reviewed in detail. One eye was in a convergent position with impaired abduction and highly myopic. Fibrous bands were visible in the periphery of the fundus of each eye, especially on the temporal side and above. The bands were outlined by dense pigment lines. They gave the impression of being atypical colobomas. The disks were partly atrophic. The patient also had microcephaly, hydrocephaly and a general hemiatrophy of the skeleton. The association of microgyria and retinal dysplasia is not surprising because the optic vesicle is a part of the diencephalon. Retinal dysplasia, however, must be ascribed to noxious influences late in fetal life while microgyria and pseudocolobomas must be identified with damages in early fetal periods, about the end of the second month. Circulatory disturbances in the region of specific branches of the posterior ciliary arteries and corresponding anomalies of the adjoining mesoderm also play an important part in the pathogenesis of the pseudocolobomatous dysplasia. (5 figures, 23 references) Alice R. Deutsch.

Dekaban, A. and Drager, G. **Metastases of the retinoblastoma to the central nervous system.** A.M.A. Arch. Ophth. 61:239-245, Feb., 1959.

Two cases of extensive metastasis of retinoblastoma involving exclusively the nervous system are reported. Both patients had previously had bilateral enucleations as well as irradiation therapy; one survived four years 10 months and the other five years two months. Since the tumor commonly spreads along neural

septa and perivascular spaces, it is suggested that consideration should be given to combining enucleation with intracranial resection of the optic nerve. This procedure has been reported several times by other authors but the subsequent study has not been adequate for proper evaluation of this method. (11 figures, 17 references) William S. Hagler.

Kreibig, W. **The formation of holes in the retina.** Klin. Monatsbl. f. Augenh. 134:34-42, 1959.

The retina, even if immediately and well fixed, may show cyst-like spaces which are artifacts and occur mainly in the ganglion cell and nerve fiber layers. In a recent article (Klin. Monatsbl. f. Augenh. 133: 87, 1958) Seitz described the pathologic substratum of the socalled "dyshoric foci." The cyst-like spaces described in this article are artifacts and these foci are probably drusen. (5 figures, 8 references) Fredereick C. Blodi.

Lijo Pavia, J. **Treatment of retinopathies and choriopathies with retrobulbar hydrocortisone and alfa quimotripsine.** Rev. oto-neuro-oftal. 33:65-72, Sept.-Dec., 1958.

The author briefly describes two groups of patients: those in the first group had moderate diabetic retinopathy and were given retrobulbar injections of hydrocortisone with some improvement in visual acuity whereas in patients who had diabetic retinopathy in its fourth stage with severe hemorrhages, vascular occlusions and retinitis proliferans, no improvement in the acuity was achieved with retrobulbar hydrocortisone.

The author also summarizes the chemical properties of alfaquimotripsine and briefly describes three patients who were given 80 to 250 units of alfaquimotripsine retrobulbarly. One of the patients had a vitreous hemorrahage due to advanced hypertension which was reabsorbed immediately after the injection of alfaquimotripsine; another with hemorrhages due to generalized arteriosclerosis also obtained an improvement in visual acuity. His third patient had hemorrhages and retinitis proliferans, due to diabetes. The retrobulbar injection of alfaquimotripsine was followed by the reabsorption of the hemorrhage and very slight improvement of the visual acuity. (34 references) Walter Mayer.

Lorente Buesa, M. **Retinal detachment in aphakia and its treatment by scleral resection.** Arch. Soc. oftal. hispano-am. 18:1096-1106, Nov., 1958.

Nine cases are reported in detail. The conclusions reached from a brief review of the literature and the author's own experience are that the pathogenesis is the same in aphacic eyes as in cases of idiopathic detachment. Scleral resection advocated by Shapland and Paufique resulted in 54 percent of success in the author's hands. Careful search for a focus of infection and its treatment will diminish the number of failures. In cases of loss of one eye from aphacic detachment, the author advocates a preliminary scleral resection followed after a time by extraction of the lens, extracapsularly if the lens is mature, and intracapsularly if it is immature. (45 references) Ray K. Daily.

Marin-Amat, M. **The new operations for cases of old and bullous retinal detachment.** Arch. Soc. oftal. hispano-am. 18:868-873, Aug., 1958.

The author refers to a previous publication in which he reported five out of seven cases of old extensive retinal detachment cured by diathermy coagulation. He deprecates scleral resection and all its variations, as well as Arruga's suture, and maintains that the results reported after those operations can be obtained with less trauma by adequate nonperforating diathermy coagulation, and sufficient perforating coagulations to evacuate the

subretinal fluid. The author emphasizes the fact that adequate nonperforating and perforating diathermy coagulation shrinks the sclera sufficiently to approximate the choroid to the retina. In a case in which he measured the size of the operative field he found that after nonperforating diathermy it shrunk from 12 to 10.5 mm. and after the perforating punctures it shrunk to eight millimeters. He stresses the importance of adequate evacuation of the subretinal fluid. Ray K. Daily.

Schappert-Kimmijser, J., Henkes, H. E. and van den Bosch, J. **Amaurosis congenita (Leber).** A.M.A. Arch. Ophth. **61**: 211-218, Feb., 1959.

During an investigation into the causes of blindness in the Netherlands it was found that approximately 18 percent of the blind children and 3.8 percent of the blind adults had Leber's amaurosis congenita. The authors studied 113 cases of this condition in children. Amaurosis congenita is inherited as an autosomal recessive and is characterized by severe amaurosis, an electroretinogram that shows either complete absence or greatly reduced photopic activity, and a polymorphus fundus picture that shows a marked discrepancy with the visual acuity. The most commonly reported fundus changes were atypical pigmentation and depigmentation in the periphery, attenuation of retinal vessels, and some degree of optic atrophy. Nystagmus is present in the majority of patients. Cataracts and keratoconus frequently occur in later stages. In the cases studied there was an increased incidence of major neurologic or psychiatric dysfunction or both, which is at variance with other reported series. Since the electroretinogram may be indistinguishable from that in cases of tapetoretinal degeneration, it may be difficult to distinguish between these two conditions. (5 figures, 9 references)

William S. Hagler.

Seitz, R. and Peters, J. **The sheathing of the retinal vessels.** Klin. Monatsbl. f. Augenh. **134**:43-53, 1959.

The authors examined histologically a number of eyes in which the vascular changes had been carefully followed with the ophthalmoscope.

Hyalinization and thickening of the media in arteriolar sclerosis accounts for grayish-white, uniform and sharply demarcated lines on both sides of the blood column apparently compressing the lumen. The more apparent white lines which blend with the surrounding tissue and which reduce the lumen are caused by changes in the adventitia and the adjacent neural tissue. This type of sheathing occurs mainly in retinal periphlebitis, endangiitis obliterans, hypertonic and diabetic retinopathy.

Fine, light yellow lines along the vessels are caused by an inflammatory exudation of fluid and cells. The lumen does not appear attenuated. This type occurs in papilledema and hypertension. (16 figures, 11 references)

Frederick C. Blodi.

Vouters, J. **Retinal endotheliitis (septic retinitis).** Arch. d'opht. **18**:262-293, April-May, 1958.

The author notes that under the term "septic retinitis," Roth described in 1872 certain benign retinal complications of septicemia which he sharply differentiated from metastatic ophthalmia. Vouters then reviews in detail the pertinent literature since Roth's original communication and reports 78 observations of his own. Color plates illustrate both clinical and pathologic observations. The author reaches the following conclusions: 1. the retinopathy is generally limited to the posterior pole in the nerve-fiber layer of the retina. It is unilateral in about half the cases. The lesions consist in hemorrhages and Roth spots; 2. the retinopathy is usually asymptomatic, 3. the retinopathy can oc-

cur in endocarditis, septicemia, suppuration, malignant tumors, and cirrhosis of the liver, 4. the essential lesion is an endothelial inflammation, and 5. Roth spots consist of degenerative changes in the retinal fibers. The author speculates on the significance of the disease and on its immunologic relationships. (7 figures, 1 table, 131 references) P. Thygeson.

12

OPTIC NERVE AND CHIASM

Chamlin, Max. **Aqueous floaters in the differential diagnosis of papillitis and papilledema.** A.M.A. Arch. Ophth. **61**:37-44, Jan., 1959.

Slitlamp biomicroscopy of the aqueous with widely dilated pupils will usually show an increased aqueous flare in cases of papillitis. The aqueous is clear in papilledema.

Papillitis may be focal or diffuse, secondary to choroidal or retinal inflammation. (3 figures, 13 references)

Irwin E. Gaynon.

Hamilton, H. E., Ellis, P. P. and Sheets, R. F. **Visual impairment due to optic neuropathy in pernicious anemia: report of a case and review of the literature.** Blood **14**:378-385, April, 1959.

A man with optic nerve involvement and pernicious anemia regained normal vision after treatment with vitamin B_{12}.

In a search of the literature we found 28 cases with both pernicious anemia and optic neuropathy. The hematologic, neurologic and ophthalmologic findings were analyzed in these cases. In each case, the diagnosis of pernicious anemia was established. Optic atrophy associated with pernicious anemia may be part of the pathologic process of pernicious anemia. If the patient is treated early with vitamin B_{12} or liver extract, optic nerve function returns. Sixteen other cases with optic atrophy and possible pernicious anemia in the literature had inadequate information to substantiate the diagnosis. The use of a cobalt^{60}-labelled vitamin B_{12} absorption test may be helpful in optic nerve disorders of obscure etiology. (3 tables, 26 references) Authors' summary.

Reese, A. B. and Carroll, F. D. **Optic neuritis following cataract extractions.** Tr. Am. Acad. Ophth. **62**:765-770, Nov.-Dec., 1958.

Optic neuritis occurring in 17 eyes, from six to 12 weeks (one occurred 10 months later), after cataract extraction is described. The disease usually lasted from five to 90 days, but in some cases normal vision was never recovered.

There was no hypotony, no uveitis, no macular edema, and no damage to the nerve was ascribed to the retrobulbar injection. The condition was bilateral in three cases. (3 figures, 2 references)

Harry Horwich.

NEWS ITEMS

EDITED BY DONALD J. LYLE, M.D.
411 Oak Street, Cincinnati 19, Ohio

News items should reach the editor by the 10th of the month. For adequate publicity, notice of postgraduate courses and meetings should be received three months in advance.

ANNOUNCEMENTS

SYMPOSIUM ON PLEOPTICS

On Sunday, October 11, 1959, at 8:00 P.M. the annual joint meeting of the American Orthoptic Council and the American Association of Orthoptic Technicians will be held in the Waldorf Room of the Conrad Hilton Hotel. The subject of the meeting will be a "Symposium on pleoptic treatment of strabismic amblyopia." Papers on the pathophysiology, diagnosis, and therapy of strabismic amblyopia, especially of amblyopia with eccentric fixation, will be presented by Dr. Gunter K. von Noorden and Dr. James E. Miller and by the Misses Geraldine L. Wilson and Nancy M. Capobianco. Dr. Hermann M. Burian, will be the moderator. There will be a question and answer period at the end of the presentations. Anyone wishing to submit written questions is urged to send them ahead of time to Dr. Hermann M. Burian, Department of Ophthalmology, University Hospitals, Iowa City, Iowa, so that adequate answers may be prepared by the panel.

ORTHOPTIC EXAMINATIONS

The annual examination of orthoptic technicians by the American Orthoptic Council will be conducted in August and October, 1959.

The written examination will be nonassembled and will take place on Thursday, August 20th, in certain assigned cities and will be proctored by designated ophthalmologists.

The oral and practical examinations will be on Saturday, October 10th, in Chicago, just preceding the meeting of the American Academy of Ophthalmology and Otolaryngology.

Application for examination will be received by the office of the Chairman of Examinations, Frank D. Costenbader, M.D., 1605 22nd Street, N.W., Washington 8, D.C., and must be accompanied by the examination fee of $30.00. Applications will not be accepted after July 1, 1959.

COURSES AT MOUNT SINAI HOSPITAL

Columbia University is sponsoring the following courses at The Mount Siani Hospital in New York City. "Gonioscopy and tonography" by Dr. Sylvan Bloomfield and Dr. Jules Yasuna, during the month of October, 1959. "Ophthalmoscopy for general practitioners and pediatricians," by Dr. Robert Coles, during the month of November, 1959. "The Schepens binocular indirect ophthalmoscope and its use," and a discussion of the indications for the various operations for the cure of detached retina. This course will be given by Dr. David Silver during the month of December, 1959.

For complete information in reference to these courses, inquiries should be directed to the Registrar for Post-Graduate Instruction, The Mount Sinai Hospital, 1 East 100th Street, New York 29, New York.

ESSAY COMPETITION

The Instituto Barraquer, Laforja 88, Barcelona, Spain, announces a competition for scientific papers on ophthalmologic subjects. Three main prizes of either five, three or one thousand pesetas will be granted for the best papers, as well as several prizes of five hundred pesetas. Regulations and conditions include: (1) Any physician under 40 years of age, Spanish or from any other country, may participate in this competition. Members of the Board of Rectors of the Institute are excluded; (2) papers must be received by December 31, 1959; (3) papers may be written in the author's own language but must be accompanied by an extensive summary (about 500 words) in English and French; (4) papers should be typed in double space, using one side of the paper only, the page number should be in the right upper corner and one word indicating the subject in the left, illustrations, tables, etc., should be on card-board, with the corresponding page number and designating word; (5) accompanying the paper should be a card with the author's full name and address in a small sealed envelope and identified by the designating word. (6) the judges will be from the Board of Rectors, assisted by the editorial board, their decision will be final.

Winners will be notified after January 31, 1960. The prizes will be distributed immediately thereafter. The winning essays will remain the property of the Institute and will be published in the *Annales of the Barraquer Institute*. Papers not winning will be destroyed after three months unless the author authorizes the opening of the envelope that contains his name and address.

EYE PATHOLOGY COURSE

The annual intensive course in eye pathology will be presented by Dr. T. E. Sanders and Dr. Albert P. Ley of the Ophthalmology Department of Washington University School of Medicine, August 3 through August 7, 1959. Further information may

be obtained by writing the Department of Ophthalmology, Washington University School of Medicine, 640 South Kingshighway, St. Louis 10, Missouri.

Miscellaneous

Edward Lorenzo Holmes award

Dr. Goodwin M. Breinin, chairman of the Department of Ophthalmology and the Daniel B. Kirby Professor of Research Ophthalmology, New York University—Bellevue Medical Center, New York, was recipient of the 1959 Edward Lorenzo Holmes Memorial Award of The Institute of Medicine of Chicago. Dr. Breinin received his M.D. degree from Emory University School of Medicine in 1943 and had his training in ophthalmology at Bellevue Hospital in New York City.

The Edward Lorenzo Holmes Memorial Award was established by the late Dr. Rudolph Wieser Holmes as a memorial to his father, a pioneer ophthalmologist in Chicago. In establishing the award, Dr. Holmes directed that it be presented in recognition of distinguished contributions in medical science, and that preference be given to contributions in ophthalmology.

This award has been made to Dr. Breinin in recognition of his important contributions in the field of ophthalmology, particularly his investigations concerning the neuromuscular control of the ocular muscles and the development of ocular electromyography in advancing knowledge of strabismus. In addition, Dr. Breinin pioneered in the study of drugs affecting the secretory epithelium of the ciliary body and their application in the therapy of glaucoma.

Dr. Franklin C. McLean, president of The Institute of Medicine of Chicago, presented the award to Dr. Breinin at a joint meeting of The Institute of Medicine and the Chicago Ophthalmological Society on May 18, 1959, in the Palmer House, Chicago, and Dr. Breinin delivered the fourth Edward Lorenzo Holmes Memorial Lecture on the subject: "Contributions of electromyography to strabismus."

Secondary glaucoma conference

A conference on "Secondary glaucoma," was presented at the University of California, San Francisco, May 21st to 23rd. The combined glaucoma and pathology staff included Drs. Frederick C. Cordes, Michael J. Hogan, Robert N. Shaffer, David O. Harrington, Levon K. Garron, William K. McEwen, Robert L. Tour, Daniel G. Vaughan, Dudley P. Bell and William H. Spencer, and Helenor C. Foerester. In order to obtain outside opinions, Drs. Earle McBain of Stanford University, A. Ray Irvine, Jr., of the Doheny Foundation, Los Angeles, and Leonard Christensen of the University of Oregon participated.

The conference considered diagnosis, treatment, and mechanisms by which pressure is raised in secondary glaucoma. A new classification, based upon etiology, was presented. By means of round-table discussion the staff systematically discussed and challenged the alleged etiology and presented approved therapy of the various disease entities. New knowledge gained by tonography and electron microscopy of the physiology and anatomy of the trabeculae was presented. New drugs and new operations were evaluated. Dr. Robert N. Shaffer, associate clinical professor of ophthalmology, University of California School of Medicine, was program chairman.

Charles Stewart Mickle award

Sir Stewart Duke-Elder, F.R.C.S., was awarded the Charles Mickle Fellowship for 1959 by the University of Toronto for his outstanding research in ophthalmology. Sir Stewart was created a Knight in 1933 and later was made a Knight Commander of the Royal Victorian Order and a Knight Grand Cross of the Royal Victorian Order. He has been surgeon-oculist to the Queen since 1952 and prior to this was surgeon-oculist to King George VI. Sir Stewart, director of research at the University of London's Institute of Ophthalmology, lectured at the University of Toronto on May 21st on "Recent advances in diagnosis and treatment of glaucoma."

The Mickle Fellowship is the income from $29,000 bequeathed by the late Dr. W. J. Mickle, and is awarded annually to the member of the medical profession who is considered by the council of the University's Faculty of Medicine to have done most during the preceding 10 years to advance sound knowledge of a practical kind in medical art or science.

Sir Stewart pioneered the early research into the cause of glaucoma, which is the commonest cause for blindness in the western world.

Societies

Joint meeting

The next joint annual meeting of the South Carolina Society of Ophthalmologists and Otolaryngologists and the North Carolina Eye, Ear, Nose, and Throat Society, will be held in Charleston, South Carolina, September 13th, 14th, 15th, and 16th. Headquarters will be the Francis Marion Hotel. The following guest speakers will lecture: ophthalomogists, Dr. Carroll R. Mullen, Philadelphia; Dr. G. Bonaccolto, New York; and Dr. Willis S. Knighton, New York. Otolaryngologists: Dr. John Bordley, Baltimore; Dr. Frederick R. Guilford, Houston; and Dr. Paul Hollinger, Chicago.

European society

The next congress of the European Society of Ophthalmology will be held in Athens in 1960. On the preliminary program are: "Hypertensive uveitis," Prof. R. Weekers, Belgium; "Glaucoma, secondary to intumescence or luxation of the lens," Dr. Stephen Miller, Great Britain; "Postoperative

glaucoma," Prof. G. Jayle and Prof. Ourgaud, France; "Glaucoma due to essential progressive atrophy of the iris," Dr. M. S. Miron and Dr. A. Willenz, Roumania; "Glaucoma due to hemorrhage in the anterior or posterior segment," Dr. L. E. Werner, Ireland; "Glaucoma capsulare," Drs. Th. Joannidès, N. Katsourakis, and P. Velissaropoulos, Greece; "Pigmentary glaucoma," Prof. V. Čavka, Yugoslavia; "Glaucoma due to proliferation of epithelium or endothelium in the anterior chamber," Prof. R. Thiel, Germany; "Glaucoma due to seclusion of the pupil," Prof. Moreu, Spain; "Glaucoma secondary to extraocular venous occlusion (pulsating exophthalmos, obstruction of the vortex veins, orbital tumors, obstruction of the superior vena cava)," Prof. G. B. Bietti, Italy; "Glaucoma in thyrotropic exophthalmos," Prof. J. Boeck, Austria; "Glaucoma due to thrombosis of the central retinal vein," Dr. S. Vannas, Finland; "Glaucoma due to rubeosis irides," Dr. Ohrt, Denmark; "Traumatic glaucoma," Dr. A. Heinc, Czechoslovakia; "Glaucoma due to intraocular tumors," Dr. F. Papolczy, Hungary; "Glaucoma in Fuchs' heterochromia irides," Dr. A. Huber, Switzerland.

Prof. Charamis has announced the program of the Congress of Athens (1960). It was decided that there would be no free communications, but only discussions and communications relating to the subjects of the reports. No one can speak more than four times. There will be films shown in addition to the reports.

The next meeting of the Council of the European Society of Ophthalmology will be held in Zurich in November, 1959. (Dr. François, Ghent.)

For information address the First Congress of the European Society of Ophthalmology, University Clinic of Ophthalmology, 26 Bd. El. Veinzelos, Athens, Greece.

Long Island Society

A symposium on remedial reading, with Dr. Conrad Berens acting as moderator, was presented at the April meeting of the Long Island Ophthalmological Society. Dr. Horace Perry, Woodmere Academy, discussed the subject from the viewpoint of the educator; Miss Mary McAssey, Board of Education, New York, from the viewpoint of the remedial reading teacher; and Dr. Berens from the viewpoint of the ophthalmologist.

British Columbia meeting

The 1959 British Columbia Oto-Ophthalmological Conference was held in Vancouver, B.C., on May 28th to 30th. Guest speakers were Dr. Alfred Huber, assistant to Professor Amsler, Zurich, Switzerland, in Ophthalmology, and Dr. T. E. Walsh, St. Louis, in Otolaryngology.

Pennsylvania meeting

Dr. Herbert J. Nevyas, Philadelphia, discussed "Electrophoretic analysis of tears," at the recent meeting of the Pennsylvania Academy of Ophthalmology and Otolaryngology. His talk was followed by a symposium of "Medical economics and public relations," with Dr. Paul C. Craig, Reading, and Dr. Robert Soemaker, Allenton, acting as moderators. Dr. Joseph F. Novak, Pittsburgh, spoke on "Health benefits from industry," and Dr. Robert Beitel, Jr., Allentown, "Union health programs."

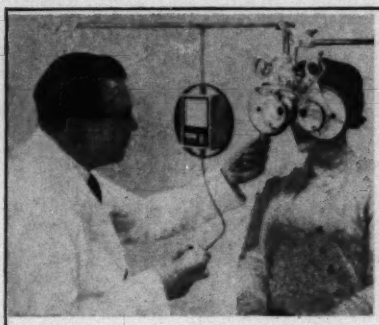
Other speakers on the ophthalmology program were: Dr. Philip Knapp, New York; Dr. Isaac Tassman, Philadelphia; Dr. Arthur Sherman, East Orange; Dr. Edwin C. Tait, Norristown; Dr. Theodore Long, Lebanon; Dr. Samuel Phillips, Allentown; Dr. William E. Krewson, III, Philadelphia; Dr. H. Walter Forester, Jr., Philadelphia; Dr. Joseph A. C. Wadsworth, New York; Dr. Joseph Alfano and Dr. David Shoch, Chicago; Dr. Robert Davies, Pittsburgh.

Personal

Dr. Harold F. Whalman, Los Angeles, received the Distinguished Nevadan Award from his alma mater, the University of Nevada, Reno, at the 1959 commencement, June 1st.

Dr. Albert D. Ruedemann, chairman, Department of Ophthalmology, Wayne State University College of Medicine, Detroit, received the Lucien Howe award from the University of Buffalo April 9th. The Howe award is given annually "to an outstanding ophthalmologist." Dr. Ruedemann is director of Kresge Eye Institute and also heads the Departments of Ophthalmology at Detroit Receiving and Harper hospitals.

Dr. Peter C. Kronfeld has been appointed professor and head of the Department of Ophthalmology, University of Illinois College of Medicine. He has also been named ophthalmologist-in-chief of the University of Illinois Hospital and the Illinois Eye and Ear Infirmary.



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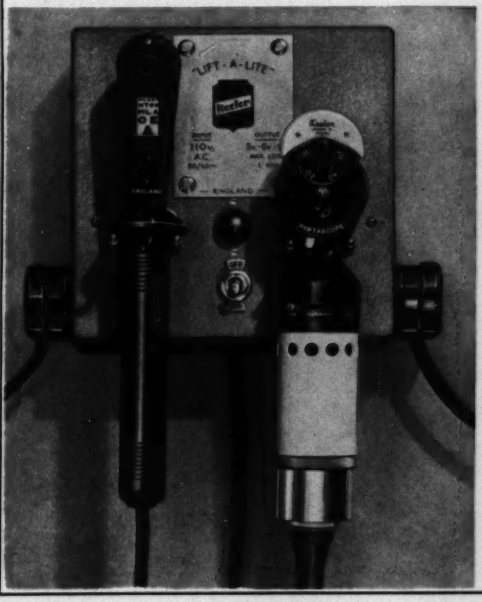

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